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STAND CHARACTERISTICS OF SELECTED ASPEN SITES ON THE WALLOWA MOUNTAINS ZONE, WALLOWA-WHITMAN NATIONAL FOREST

Stand Characteristics of Selected Aspen Sites on the Wallowa Mountains Zone, Wallowa-Whitman National Forest

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Preface

The primary objective of this report is to summarize data collected in aspen stands on the Wallowa Mountains Zone during 2000. The sections on aspen ecology, project objectives, area description, problem analysis, methods, and literature review were taken directly from Aspen Ecology and Rehabilitation in Eastern Oregon (Wall et al, 1999). The rest of the report presents summaries of and raw data for aspen stands surveyed in 2000. This information will enable land managers to prioritize stands for rehabilitation efforts as well as guide future work in this unique habitat.

Aspen Ecology and Rehabilitation in Eastern Oregon

Introduction

It is generally accepted that aspen stands in the Blue Mountains and northern Great Basin are in an ongoing state of decline. In some cases only one or two trees remain in the stand, and it is reasonable to conclude that extensive stand loss has occurred during the last several decades. Aspen in the Blue Mountains did not exist in extensive (several hundred acres) stands common to the Rocky Mountains and Great Basin. Aspen typically occur as isolated stands in the uplands where soil and moisture conditions were favorable, which often involved perched water tables, and as stringers along stream corridors. Reasons for the decline of aspen are complex but are frequently attributed to fire suppression, conifer encroachment, past and present herbivory (elk, mule deer, and cattle), climatic stress and interactions of the aforementioned possibilities. Particularly important is the role of herbivory as fencing to exclude elk, mule deer and cattle increases the cost of rehabilitation efforts.

Aspen stands enhance biodiversity at the landscape level and provide habitat for a variety of birds and mammals. However aspen stands, through mortality and lack of recruitment, are declining to smaller and smaller core areas and fragments. Important to restoration is knowledge of past aspen stand physiography and structure, and identification of factors contributing to the decline of aspen. Aspen stands, because of their lack of regeneration by seedling establishment, are restricted to present locations. Therefore the only way to retain aspen as a component of the Blue Mountain forests and Northern Great Basin rangelands is to reinvigorate existing stands. Given the aforementioned possibilities attributed to the decline of aspen, several rehabilitation methodologies are being employed to restore stands. These methods have a high cost per acre and due to limited monitoring across public and private agencies their effectiveness has not been determined at the landscape level. Therefore, it is desirable to evaluate methodologies used and develop an intensive and statistically designed study to evaluate the best possible rehabilitation practices. Increasing the general knowledge base of aspen ecology should also assist in developing the most effective rehabilitation methods.

Project Objectives

The primary objectives are:

1) Field reconnaissance of existing stands in the study area with emphasis on identifying historic extent of aspen.
2) Monitoring ongoing USFS and BLM inventory work.
3) Assisting or supplementing ongoing USFS and BLM inventory work in locating stands and sites.
4) Describe stand structure, age, and conifer encroachment of existing aspen stands.
5) Identify and evaluate exclosures; and previous, ongoing, and planned stand treatment projects.
6) Obtain funding for an extensive proposal to study aspen ecology and evaluate and monitor rehabilitation methods in these unique environments.

7) Continue to work with all interested potential partners or cooperators, and volunteers.
8) Develop a progress report for the RMEF, USFS, BLM, ODFW, and BMEI that summarizes the field work. EOARC staff will be available for presentation of results to cooperators.

From the stated objectives we hope to 1) develop a better understanding of the past and present status, and trend of aspen; 2) identify aspen rehabilitation methods and evaluate their level of success; 3) identify factors leading to aspen decline; 4) develop a working partnership between EOARC, BLM, and USFS to initiate an intensive study of aspen in the Blue Mountains and northern Great Basin that will provide managers with methodologies that have a high expectation of success and increase the knowledge base of aspen ecology.

Area Description

The Burns, Bear Valley and Prairie City Ranger Districts of the Malhuer National Forests lie generally south of the cities of John Day and Prairie City and north of Burns, Oregon. The Three Rivers Resource Area, Burns District, BLM abut the Malhuer National Forest study areas on the south. The area is dominated by ponderosa pine forest with north slopes at mid and higher elevations having mixed conifer communities. Lodgepole pine communities are also present at the mid and higher elevations. Aspen stands are found as stringers along stream channels, adjacent to wet meadows, or as isolated communities in the uplands where soils and moisture permit. Elk, mule deer, and cattle are common grazers over the entire area. The study area lies within the Murderer's Creek, Silvies, and North Malheur Big Game Management Units where, in 1997, hunters harvested 657, 860, and 435 elk, respectively.

The Sheep Creeks/Imnaha Collaborative Stewardship Initiative (SCICSI) Planning Area is located in eastern Wallowa County, within the northeast corner of the Blue Mountains Ecological Province. The planning area encompasses approximately 150,000 acres of mid-elevation (3-5,000 ft) forest and grassland habitat within the Imnaha Subwatershed of the Snake River Drainage. The ridgetops are dominated by native bunchgrass communities. These grasslands provide habitat for a wide range of wildlife species including deer and elk. A resident herd of 1,000 elk use the planning area as winter and transitory range during spring and fall. Numerous forested draws create a classic, grass-tree mosaic habitat on the slopes. These provide good habitat for deer and elk with cover and forage in optimum juxtaposition. At the heads of the draws are substantial remnant hardwood communities of aspen, hawthorne, upland willows, mountain ash, and serviceberry. Approximately 100 aspen clones have been mapped within the planning area. Some of these clones are within existing exclosures or have received other treatments. The planning area is a mixture of USFS (>70%), private (<20%), Oregon Nature Conservancy (3%), BLM (<10%) and Oregon Department of Fish and Wildlife (<5%) lands.

In the Great Basin Aspen stands typically reside along the north and northeast base of ridges where wind deposition causes excess snow accumulation. Aspen stands

vary in elevation from 5,000 to 8,000 feet. Within the elevation, yearly precipitation varies from 12 to 16 inches. However, excess snow accumulation increases available moisture enabling these sites to sustain aspen in an otherwise semi-arid environment. Associated plant communities are predominantly mountain big sagebrush with various degrees of low sagebrush, rabbitbrush, bitterbrush, and snowberry with fescues, wheatgrasses, and needlegrasses. Tree communities include western juniper, mountain mahogany and aspen. The geography is typified by desert basins, uplands, canyon and fault block mountains. Elk numbers are increasing within this geographic area. Mule deer, pronghorn and bighorn sheep are also inhabitants.

Problem Analysis

Aspen communities have been identified as important habitat components of the Blue Mountains and northern Great Basin. Similar categorization has occurred for aspen throughout the entire western U.S. Aspen stands provide ecological as well as aesthetic diversity to the landscape; forage and cover for ungulates; nesting, feeding and migratory habitat for a variety of avian species; and habitat for a wide variety of small mammals. Additionally, they are sought out by people as camp sites. Generally, aspen communities are declining throughout the western U.S. Various hypotheses have been expressed as to the cause thereof. Herbivory by elk, deer, and cattle has been implicated as a primary factor in aspen decline. Fire suppression, conifer encroachment, and climatic cycles have all been implicated as well. There is an immediate need to reverse this trend, as aspen may be currently present at only 5% of pre-settlement occurrence. Remnant aspen stands typically occur as small units of perhaps as little as one to five stems and less than one acre in size in the Blue Mountains. In the northern Great Basin stands are typically larger in size but lacking in diverse age structure and recruitment. Due to the high palatability of aspen to ungulates, most rehabilitation methods in the Blue Mountains include fencing. Burning, conifer thinning, and removal of mature aspen stems are treatments commonly used separately or in aggregate to regenerate stands through the action of sprouting. Costs of projects can vary from $1,000 to $1,500 per acre. Due to this high cost and the number of aspen stands, there is a need to identify the most successful methods of rehabilitation.

Sample Methods for Assessing Response to Aspen Treatments

Site selection

1st Priority

Aspen sites that have been treated or will be treated for the purpose of enhancing stand vigor and regeneration.

2nd Priority

Aspen sites that are not scheduled for treatment. These sites allow for comparisons with treated aspen as well as assessing condition and trend of aspen across the landscape.

Site information

Each site sampled is assigned a permanent identification number for the purpose of record keeping and communication. Sites previously numbered are not re-numbered. The date sampled, general location, landform, treatment type, percent lost, and vigor rating of the site is recorded (see Appendix 1).

Landform types have been broken down into the following categories:

1. Seep. Drainage areas where water is evident in the soil but not free flowing or standing as in riparian classification.
2. Non-seep, but sub-drainage. Drainage areas where water is not evident above ground.
3. Riparian. Areas adjacent to springs, streams, ponds, or other types of open flowing or standing water etc.
4. Meadow.
5. Upland. Areas with no apparent ties to concentrated water drainage or source.

Treatment types will vary but may include the following:

1. Four wire fence.
2. Big game wire fence.
3. Buck and pole fence.
4. Cages.
5. Aspen cut.
6. Aspen burned.
7. Conifers cut.

All aspects of a treatment are recorded. For example a site may have a 4-wire fence with 9 cages and half of sub-dominant conifers cut.

To determine where the aspen stand once existed the following criteria were used:

1. Distribution of dead down aspen.
2. Distribution of outlying aspen sprouts/saplings.

By using these criteria a visual estimation is made as to what proportion of the stand has been lost.

Vigor of aspen sites are assessed following methods created by Mike Tatum, Silviculturist PCRD (see Appendix 2).

Sampling

Plot size

A 30m (98ft) diameter circular plot was located inside the stand to be sampled. The plot is located to best represent the site as a whole.

Density

Aspen and each species of conifer are separated out into the following categories and counted.

1. Sprout/sapling. Trees less than 2m (6.5ft) tall.
2. Sub-dominant. Trees greater than 2m (6.5ft) tall but not part of the co-dominant canopy.
3. Co-dominant. Classed as height of adult aspen.
4. Dominant overstory. Conifers taller than co-dominant.

Standing dead and large down dead aspen are categorized in one of the above categories and counted. Note that only those down dead aspen that were rooted within the circular plot are recorded. In sites where aspen sprouts/saplings are very dense a 15m (49ft) circular subplot located in the center of the existing larger plot was used. The subplot is sectioned into four equal quarters. Two quarters are randomly selected and the aspen sprouts/saplings are counted within these two quarters. If this is done then it is noted on the data sheets next to where these tree densities are recorded (i.e. sampled ½ 15m).

Canopy cover

A spherical densiometer is used to determine aspen and conifer canopy cover for each plot. Conifer canopy cover is not separated out by species but is measured as a total. Densiometer measurements are recorded for five locations; one reading in the center of the circular plot and additional readings at the north, south, east, and west edge of the circular plot.

Canopy height

Sprout/sapling and co-dominant aspen and co-dominant and dominant conifers canopy heights are measured and recorded. If aspen sprout/sapling class shows evidence of being browsed (i.e. multi stemmed hedged appearance, terminal leaders absent) it is recorded. If current years growth has been browsed then it is recorded.

Stand age

In every site sampled, five of the largest aspen were cored at dbh with an increment wood corer. Ten conifers are cored at dbh with 5 being in the sub/co-dominant class and 5 in the dominant class. Note that cored trees do not have to be inside the circular plot and that 5 of each class may not be present to core. Record how many of each class was cored. Each individual tree core is labeled with the forest, district, site number, tree species (i.e. conifer or aspen), dbh, and class (i.e. co-dominant or dominant). Cores were mounted, sanded, and rings counted. All aspen cores were stained prior to counting.

Plant component

The primary and secondary species of shrubs, grasses, and forbs are recorded and ranked according to the following cover classes:

1. <1%
2. 1-5%
3. 5-15%
4. 15-25%
5. 25-50%
6. 50-75%
7. 75-95%
8. 100%

Site geography variables

Slope, position on slope (crest, mid, toe), aspect, elevation, and micro-relief (convex, concave, flat) are all recorded.

Literature Review of Aspen

Distribution

Quaking aspen (*Populus tremuloides*) is the most widely distributed native North American tree (Baker 1925, Fowells 1965, Jones 1985, Weber 1990). Aspen thrives from the hardwood forests of eastern North America to the coniferous forests in the Rocky Mountain west. It grows in a wide variety of sites varying from gentle slopes with deep soils to valley bottoms, riparian areas, and steep high talus ridges (Morgan 1969). Soil types vary from loamy sands to heavy clays (Shepperd 1986).

Mueggler (1988) stated that aspen-dominated woodlands constitute a major portion of forest types in the interior West. The Intermountain Region contains over 1 million ha of aspen forests. DeByle et al. (1989), reports 3 million ha of aspen in the West. These forests range from small isolated groves to broad expanses of pure and mixed stands.

Utah's extensive stands of aspen occupy more of its forested land (25%) than any other tree species (Mueggler 1988; Jones 1985). Idaho and western Wyoming combined have 323,000 ha of widely distributed isolated stands (Mueggler 1988). Idaho's aspen occupy a greater diversity of geographic areas than in any of the other intermountain states (Jones 1985).

Aspen is associated with montane and subalpine vegetation types along a broad elevational and moisture gradient (Shepperd 1986). Elevation levels of aspen in the Intermountain Region range from a high of 3,350 m in Utah to a low of 914 m in central Idaho (Jones 1985). Across this wide elevation zone annual precipitation ranges from 40 to 100 cm per year, most being received as snow (Shepperd 1986).

Amacher and Bartos (1997) currently estimate that aspen dominated lands in the Intermountain West have decreased by 60% since European development. In the Rocky Mountain region, Utah alone has had an approximate 60% decline in aspen dominated landscapes due to conifer encroachment (Bartos and Campbell 1998). Kay and Wagner (1996) state that aspen in Yellowstone Park have declined by 85% since 1947 due to ungulate browsing. Bartos and Campbell (1997), state that when conifers overtake aspen communities, less water is available to the watershed, under-story biomass vegetation is significantly reduced, and the diversity of wildlife and plant species declines.

Comparing seral and stable aspen communities

The main question regarding succession is whether present-day aspen stands are seral or climax communities. To be considered climax, a species must reproduce within the community and/or provide an environment unfavorable for the successful invasion of a potential climax species (Morgan 1969). In general, aspen has been regarded as a fire-induced successional species that dominates a site until more shade tolerant conifers begin replacing the stand (Mueggler 1985a; Bartos 1973; Morgan 1969). Without periodic fires, conifers reproduce in their own shade, out-compete aspen, and move the site's composition towards climax. Such conifers may include *Picea engelmannii, P. pungens, Abies lasiocarpa, A. concolor, Pinus contorta, P. ponderosa, Pseudotsuga menziesii,* and *Juniperus occidentalis.*

Long fire intervals are required if conifers are to replace aspen stands. Long intervals enable conifers to establish, reproduce, and become the dominating climax species. However, fire interval length can vary. Depending on the site and the conifer species, conifers can replace aspen stands within a single generation or up to a 1,000 years in the absence of fire (Mueggler 1985a). A reliable determinant of a seral aspen site is the presence of an uneven-aged conifer under-story (Mueggler 1985a, Peterson and Squires 1995).

For conifers to replace an aspen stand there must be an initial population to provide a seed source. Conifers do not reproduce vegetatively like aspen, so without a seed source, they will not establish. The viability, fecundity, and number of seed help ascertain the rate of conifer establishment.

An aspen stand classified as a climax community has key indicators of stability. Stands with an uneven-age structure in the canopy over-story indicate trees are reproducing in the absence of disturbance. The fact that the stand is reproducing in its own shade may qualify a stand as climax. However, there must be lack of successional change in the under-story and the absence of more shade tolerant trees (Mueggler 1985a, Shepperd 1986). A stable aspen community may contain a few scattered conifers due to highly unusual and temporary conditions that favored their establishment. However, conifers must be prominent with an uneven-aged under-story to suggest a seral aspen stand (Mueggler 1985a).

Pure aspen stands exist in which no conifers are present. On Steens Mountain in southeast Oregon, no conifers (western juniper) are found above 7,000 ft. Aspen stands above this elevation are exempt from shade tolerant conifers and further successional development. These stands can be classified as climax.

Daubenmire's polyclimax theory suggests that aspen stands that burn at regular fire intervals can be classified as a pyric climax. Regular fire intervals deter conifer development and allow aspen regeneration to continue. Without periodic disturbances, stands are considered seral and succession of conifers will progress (Daubenmire 1968). Environmental conditions determining aspen's role, as a seral or climax species have not been determined (Mueggler 1988).

Asexual reproduction

Aspen is unique in its ability to reproduce asexually and sexually. In the Intermountain Region, aspen mainly reproduce asexually through suckering, a process in which stems are produced from the connected underground parent root system (Schier 1975, Schier and Smith 1979, Schier et al., 1985a). These stems, or ramets, are genetically identical to each other. Because of this, distinct aspen stands are often referred to as clones. The production of suckers greatly increases when over-story stems are removed by disturbance such as fire, wind, and cutting. Suckers are also produced when over-story stems die from disease or old age. This vegetative method of reproduction results in clones of genetically identical trees and stands of a single genetic individual. Because of asexual reproduction, stands or clones can be quite large. Many believe that the largest living organism on earth is a clone of aspen named Pando in south-central Utah (Grant et al. 1992, Grant 1993, McLean 1993, Mitton and Grant 1996). Through time, ancient clones could result from asexual reproduction. Figures of

10,000 to 1 million years old have been proposed (Barnes 1966, Kemperman and Barnes 1976, Mitton and Grant 1996).

Sucker development in aspen roots is suppressed by auxins transported from aerial parts of the tree (Schier 1976, Schier et al., 1985b). The loss of the over-story stems causes hormonal imbalance and apical dominance is lost. Auxin levels decline and buds located just below the soil surface on lateral roots are stimulated to sprout and grow (Schier 1972, Schier 1976, Shepperd 1986). Under favorable conditions, almost any section of an aspen root can sucker since lateral roots have thousands of suppressed shoot primordia (Schier et al., 1985b).

Undisturbed aspen stands that contain large numbers of suckers indicate that apical dominance is not absolute (Schier et al., 1985b). Auxins are unstable compounds that are translocated over lengthy distances from buds and young leaves down to roots. As auxins travel down the stems, apical dominance is weakened due to auxin immobilization, destruction, and age (Schier et al., 1985b). Periods can occur in the growing season when apical dominance is weak enough to allow suckering. This allows stands to reproduce without disturbance. This supports the earlier discussion of climax aspen stands.

Elongating suckers depend on parent root reserves until they can photosynthesize. Sucker population of a clone is related to levels of reserved carbohydrates and hormonal growth promoters in the roots (Schier 1976, Schier et al., 1985b). Once the sucker begins assimilation of carbon, additional roots sprout from the parent root near its base. The degree of dependence on parent roots declines as these roots develop to provide water, nutrients and support for that specific stem (Jones and DeByle 1985).

Soil temperature is considered the most important environmental factor controlling suckering (Steneker 1974, Schier 1976). Increased temperatures raise cytokinin levels in root meristems and degrade auxin concentrations. Suckering is then stimulated by the higher ratio of cytokinin to auxins (Schier et al., 1985b). Canopy removal allows greater amounts of light to reach the soil surface, which increases soil temperatures, and suckering. Also, stand-replacing fire can leave black soil surfaces that are conducive to light absorption and soil heating.

Several researchers have studied sucker regeneration after clearcutting, partial cutting, scarification, and girdling of adult aspen. Schier and Smith (1979) found that clearcutting resulted in the highest number of suckers. In Colorado, Crouch (1981) found that clearcutting mature aspen resulted in 18,000 sprouts/acre after the first season of growth and 8,000 sprouts/acre after two growing seasons. After two growing seasons sprouts were 4.4 feet tall. In Arizona, Jones (1975) found that clearcutting mature aspen resulted in 14,000 suckers/acre after the first season of growth and 10,700 suckers/acre after four growing seasons. After four growing seasons suckers were a maximum of 10.5 feet tall. Jones (1976) states that partial cutting of adult aspen results in an inferior replacement stand. However, clearcut stands have rapid and abundant regeneration. Schier and Smith (1979) concluded partial cuts had less than 50 percent of regeneration as clearcuts. Girdling was not as affective as cutting and few suckers survived longer than 12 years on girdled plots. Scarification had no measurable effect on sucker production. Smith et al. (1972), also found that girdled plots of adult aspen resulted in far less sucker production versus cut plots of adult aspen.

Sexual reproduction

Aspen is dioecious, with male and female flowers borne on separate trees. Flowering generally occurs in early spring before the appearance of leaves (Jones and DeByle 1985). Aspen seed production and subsequent colonization strongly depends on favorable climatic and microclimatic conditions. Reproductive maturity is reached at 10 to 20 years of age. Peak seed production occurs at 50 years with varying years of light to heavy seed crops (McDonough 1985). A mature tree is estimated to produce 1.6 million seeds a year (Maini 1968, McDonough 1979).

Aspen's ability to produce sufficient seeds for establishment is offset by the exacting conditions required by germinating seed and seedlings (Pearson 1914, Baker 1918, McDonough 1985). Factors involving germination, viability, and water stress, affect seedling growth and survival (McDonough 1985; Shier et al., 1985a; Morgan 1969). Temperatures greater than 25 C at the soil surface inhibit seed germination. Elevated temperatures from fire blackened soil surfaces stimulate sucker sprouting but are not conducive to seed germination. In a dry, warm environment seed viability typically lasts 2-4 weeks after maturation, limiting the time for establishment (McDonough 1985; Morgan 1969). Exposure of seed to high temperature and humidity results in a rapid loss of germability (McDonough 1979). Additionally, root hairs from the germinating seed dry rapidly if they fail to quickly penetrate the soil surface and make contact with water (McDonough 1985). Thus, conditions for establishment are delicate. In the Intermountain Region, current climatic conditions are not favorable for sexual reproduction. McDonough (1985) and Mitton and Grant (1996) have proposed that climatic conditions favorable for seedling establishment have not been present in the West for the past 10,000 years, or since the last glaciation.

Age structure

Aspen stands can be categorized as young, mature, old, and uneven-aged. The following paragraphs describe each age class:

Young stands are found where a recent disturbance or disease has killed the over-story and triggered vegetative reproduction (Shepperd 1986). Disturbance such as fire removes the stand in a single event allowing for uniform sucker growth with an even age distribution. These stands can contain 49,000-75,000 suckers/ha that thin over time because of competition for sunlight (Jones 1976, McDonough 1985).

Mature even-aged stands are 80 to 100 years old with tree height ranging from 9 to 30 m (Mueggler 1985). An estimated two-thirds of the aspen stands in the Intermountain Region exceed 95 years of age (Mueggler 1989). Stands reaching ages greater than 120 years are classified old (Bartos and Mueggler 1981). Some stands have been reported to persist for more than 200 years (Bartos and Mueggler 1981). At this point, deterioration becomes evident and trees begin to die (Jones and Schier 1985).

Uneven-aged stands contain multiple age levels of young, mature, and old trees. These stands form under stable conditions where the over-story progressively dies from age or disease and is consecutively replaced by suckers (Mueggler 1985). Uneven-aged stands can also be found where individual clones expand and invade into adjacent grass or shrub communities (Mueggler 1988).

Stand dynamics

Mueggler (1988) states that most aspen communities are multi-layered because light penetration into the aspen over-story is sufficient to support abundant undergrowth. This undergrowth is comprised of shrubs, perennial herbs, and annuals. Aspen stands can be complex with several layers of conifers, shrubs, tall forbs, low forbs, and grasses. In contrast, stands can be very simple with even-aged aspen and a general assembly of grasses. He further shares that among the hundreds of plant species present in aspen communities of the Intermountain Region, very few can be considered representative of the aspen type. He feels that this reflects the ability of aspen to serve as an over-story dominant under a broad range of environmental conditions.

In discussing his methods of classifying aspen community types, Mueggler (1988) does generalize those plant species most likely to be found. Shrub genera include: *Symphoricarpos, Rosa, Amelanchier, Prunus*, and *Berberis*. Forb genera include: *Thalictrum, Osmorhiza, Geranium, Aster, Lathyrus, Achillea*, *Galium*, and *Senecio*. Graminoid genera include: *Agropyron*, *Bromus, Elymus, Poa*, and *Carex*. Of 2,100 aspen stands sampled by Mueggler (1988) only four plant species occurred more than half the time. These include: *Symphoricarpos oreophilus, Agropyron trachycaulum*, *Achillea millefolium*, and *Thalictrum fendleri*.

Mueggler (1985) points out that seral stands of aspen giving rise to conifer development become depauperate of previous plant species. When the conifer layer thickens, less light penetrates to lower levels of the under-story and competitive relationships are altered. This results in a progressive decrease of under-story shrubs and herbs.

Soils

Aspen is found on soils derived from basalt, granite, sandstone, and limestone (Berndt and Gibbons 1958, Jones and DeByle 1985). Aspen grow on almost any soil type originating from these parent rocks. This broad amplitude of growth success is attributed more to environmental factors than actual soil types (Jones and DeByle 1985).

According to Jones and DeByle (1985), aspen has been observed on a full spectrum of landforms, including bottoms of draws, tops of ridge crests, and on tops of mesas and plateaus. Aspen have been observed on gley soil next to marshes, on 73% slopes of an old avalanche track, and on old talus with very thin stony soils. This wide spectrum of aspen stand locations explains why numerous types of soils are represented. However, aspen does grow larger and faster at the foot of slopes and on benches. These areas are well suited for aspen because they can contain rich, deep soils with plentiful moisture (Baker 1925, Jones and DeByle 1985). Heights depend upon site quality and clonal genotype.

Bartos and Johnston (1978) found the highest concentration of nutrients in aspen were in leaves and new twigs. Bartos and DeByle (1981) state that the annual return of leaf and twig matter to the soil surface is a major contribution to the organic matter and nutrient content of soils under aspen. Their study revealed that nearly 1,800 kg's per

hectare of aspen leaves and twigs fell each year from stands with basal areas ranging from 17 to 25 square meters per hectare. Further study revealed that a 42% weight loss in the litter crop occurred after the first year. Such high decomposition rates suggests these communities have rapid nutrient cycling. On deep, well-drained soils, varied rooting depth of aspen allows for effective withdrawal of large quantities of available nutrients. These nutrients are incorporated into biomass. A large proportion of that biomass is annually dropped as litter to the soil surface where it decays rapidly and returns nutrients to the mineral soil. This cycle builds and enhances soil (Jones and DeByle 1985).

Aspen leaves typically have a higher nutrient content than conifer needles and are able to decay faster (Duabenmire 1953, Troth et al. 1976, Bartos and DeByle 1981, Jones and DeByle 1985). Herbaceous undergrowth is usually more productive under aspen than under conifers. This provides for even more litter input to the soil (Morgan 1969).

Soil studies done in northern Colorado found the A1 soil horizon under aspen was darker and contained more organic matter than under adjacent coniferous stands (Hoff 1957, Jones and DeByle 1985). Another study in northern Utah revealed that the top 6 inches of mineral soil under aspen had 4% more organic matter, slightly higher pH, more available phosphorus, and a higher water holding capacity than the soils of adjacent stands of shrubs and herbaceous vegetation (Tew 1968, Jones and DeByle 1985).

Jones and DeByle (1985) believe that if aspen occupies a site for several generations, an aspen type soil develops. If the aspen is seral to conifers, then the soil exhibits influences of the vegetation that occupied the site for the longest period of time. A single generation of conifers may result in a leached, light colored A2 horizon. This layer would be darker and more nutrient rich under aspen dominant sites.

Amacher and Bartos (1997) conducted a study where they sampled soils that at one time were dominated by aspen. Due to lack of fire, wildlife use, grazing livestock, or natural succession, conifers or sagebrush had largely replaced them. They measured pH, exchangeable cations, extractable phosphorus, total organic carbon, total nitrogen, and organic matter content of soils developed under conifers, mixed conifer-aspen, and aspen stands. Their studies found no significant differences for these measured soil properties. They felt that the soils had not been altered significantly to inhibit new aspen development. However, soils were sampled in the interspaces between trees, not directly under trees (personal communication). Wall (1999) sampled soils that once were dominated by aspen but presently were dominated by western juniper. Soils were collected directly under aspen and western juniper trees. The C:N ratio and pH proved to be significantly greater in soils collected under western juniper. Soils influenced by western juniper also had higher amounts of salts, lime, and sulfate, and lower amounts of magnesium, iron, manganese, and copper.

Fire

Fire is a natural event in aspen communities that plays an important role in perpetuating stands (Baker 1925, Schier 1975, Bartos and Mueggler 1981; Brown and DeByle 1987; DeByle et al. 1987, DeByle et al., 1989). It is responsible for the abundance of aspen in the West (Jones and DeByle 1985; Romme et al., 1995). Fire stimulates the production of suckers by nullifying apical dominance through the removal of the over-story (Schier 1975, DeByle et al. 1987, Bartos et al., 1991). Prior to

European settlement fire occurred regularly at varying intervals. With the settlement of the West, these intervals have lengthened due to fire suppression and alteration of fuel loads. Today fire in aspen stands is considered an unusual event (DeByle et al., 1987, DeByle et al. 1989). The lack of fire has resulted in old decadent aspen stands throughout the West (Schier 1975, Jones and DeByle 1985, DeByle et al., 1989).

The current dominance of aging, decadent aspen stands concerns land managers (Basile 1979, DeByle et al. 1989). Managers desire a more favorable multi-aged mosaic of aspen stands (Harniss and Bartos 1985, DeByle et al. 1989). Therefore steps are being taken to rejuvenate decadent stands on public lands. Re-introduction of fire through prescribed methods kills invading conifers and removes over-aged aspen. Vigorous growth of the new even-aged root suckers enhances the favorability of the community.

Aspen stands require certain conditions for fire to occur. They do not readily burn as other vegetation types that have evolved flammable characteristics (Mutch 1970, Bailey and Anderson 1980, Jones and DeByle 1985, DeByle et al. 1987). In the Great Basin adjacent mountain big sagebrush stands burned every 12 to 25 years (Miller and Rose 1999). However, aspen only burned during very severe fire events. A dense under-story of conifers or shrubs combined with dry conditions favor a hot fire with rapid spread. Many aspen stands lack these larger fuel loads and only have fine herbaceous material, fallen leaves, occasional downed stems, and a few shrubs or conifers (Jones and DeByle 1985). Fires that occur in these fuel loads are generally lower intensity creeping ground fires and not the higher intensity fires of conifer/shrub stands. Jones and DeByle (1985) state that aspens sensitivity to fire negates the difficulty of these stands to burn and allows for vigorous sucker regeneration. However, Basile (1979) found that although fire increases suckering, the response is highly variable.

Key factors that influence fire temperatures include fuel type, quantity, spatial distribution, moisture content, and weather conditions prior to and during burning (Bailey and Anderson 1980). Aspen is not readily burned due to relatively high fuel moisture, but because its bark is thin and green without protective corky layers, it is very sensitive to fire heat. Fire kills trees or inflicts damaging scars that lead to root and heart rot (Baker 1925, Jones and DeByle 1985). Fire that is able to kill the over-story stimulates profuse suckering (Bartos and Mueggler 1981). In Wyoming, severely burned sites generated the most suckers, 2 years after the fire. Moderate to light burned sites produced the most suckers, 1 year after the burn. On both sites, suckers numbered from 29,900 to 150,000 stems per hectare (Bartos 1979, Jones and DeByle 1985). It is suggested that 10,000 to 20,000 suckers/ha are needed initially to re-establish aspen on burned sites (Bartos et al., 1991).

Animal impacts

Aspen communities regularly produce more that 2,000 kgs of forage/ha (Houston 1954, DeByle 1985a). This rivals the production of grasslands and can exceed neighboring conifer communities by 6 times (Reynolds 1969). Young aspen is nutritious, and when abundant, will make up a substantial portion of livestock and wild ungulate diets (Mueggler 1985b). Today the primary consumptive use of aspen growth and under-story is grazing by cattle and sheep (DeByle 1985a).

In a given area, the proportion of aspen acreage is relatively small when compared to the overall acreage available for livestock use. However, these stands can be and have been greatly affected by livestock herbivory. Cattle and sheep contribute different methods of disturbance. Cattle stocking rates resulting in utilization levels of 50-60% of the palatable forage has negligible affects in both mature and young sucker stands of aspen. In contrast, similar levels of grazing by sheep will damage and kill the aspen suckers (Sampson 1919, DeByle 1985a). Sheep browsing directly impacts aspen in the early sapling stage by reducing growth, vigor, and numbers (DeByle 1985a). Repeated over-browsing will eliminate an aspen stand. Sampson (1919) states that aspen suckers need to be 1.2 m tall for terminal leaders to escape sheep utilization; suckers need to be greater than 1.5 m tall for terminal leaders to escape browsing by cattle. Utilization of aspen and terminal bud removal is greater on sites used by both domestic and wild ungulates versus utilization by only one ungulate type (Smith et al. 1972).

As a growing season progresses, cattle increase use of herbaceous species in aspen stands as the availability of forage outside the stands declines (Fitzgerald et al., 1986). On the other hand, sheep select for the forage in these stands regardless of the season. Despite season of use and foraging, cattle do negatively impact these sites by seeking shade and constantly trampling stands. Repeated sucker damage progressively deteriorates the stand until only a few decadent trees remain. Fitzgerald and Bailey (1984) found that on burned aspen stands two different plant communities resulted from two cattle grazing regimes. After the first year, early grazed plots consisted of 29% aspen and 28% grass, while late grazed plots had 2.5% aspen and 18% grass. They concluded heavy browsing by cattle in August reduces aspen suckers following fire.

Reduced fire intervals in aspen stands are partially attributed to removal of under-story vegetation by livestock (Jones and DeByle 1985). Normally this vegetation dries in the fall allowing for potential fuel loads to carry fire. Stands that do burn must be protected to ensure sucker survival. Fencing or piling slash can be used to deter livestock use. This gives suckers opportunity to establish and grow to a needed height of 1.5 m to protect the terminal meristems from damage caused by ungulate use (Jones and DeByle 1985).

In Arizona, Shepperd and Fairweather (1994) removed a fence surrounding a 6.5 ha aspen sucker stand. The site had been fenced for five years after clearcutting. The regenerated stand averaged 50,000 stems/ha with dominant stems over 3 m in height. By one year after fence removal, elk had caused severe damage to the stand by breaking the stems to reach the terminal foliage. Subsequently, cytospora canker infected the damaged stems. They concluded that fencing needs to remain in place 10 to 15 years due to the demand for browse associated with current high animal populations. In New Mexico, Patton and Avant (1970) state that six to eight years of protection after a fire is needed to allow suckers to escape utilization by deer and elk.

Wild ungulates, such as deer and elk, seasonally rely on aspen stands. Aspen suckers are not a significant forage source during the summer months (Canon et al. 1987). The season of primary use is during fall and winter when elk and deer seek food and thermal cover. Deer browse heavily at this time. Their average diets include 74% trees and shrubs (Kufeld et al. 1973, DeByle 1985a). Deer reside in and around aspen stands during fall and early winter until snowpack depth in the aspen zone forces them to lower elevations. Elk are larger and able to remain in aspen zones during most winters

(DeByle 1985a). Their evidence of residency is regularly depicted due to elk "barking" mature aspen stems. Barking is the process of gnawing or stripping the bark for food. Elk are the primary barkers of the West, but rabbits, hares, mice, voles, and porcupines also contribute. Excessive barking can girdle trees or allow pathogenic fungi and canker to infect and adversely affect the aspen stand (Packard 1942, DeByle 1985a; Romme et al. 1995). For example, Krebill (1972) found that stands of aspen on the Gros Ventre elk winter range had an unusually high mortality rate due to the combination of pathogenic fungi, injurious insects, and physiological stress that follows bark wounding by elk. Baker et al. (1997) report that over the last century aspen regenerated only when there were less than 600 elk on the Rocky Mountain National Park's winter range. Presently there are an estimated 1,600 elk. They feel that excessive elk browsing, rather than fire suppression or climatic fluctuations, is limiting aspen regeneration. They state this was not the case prior to EuroAmerican settlement because pre-settlement elk populations were not of significant size to deter aspen regeneration.

Excessive or highly concentrated populations of deer and elk are a major concern to the health and longevity of the aspen community. Aspen communities found on winter ranges receive the most damage (Romme et al. 1995). The combination of human encroachment on winter range and subsequent fire suppression has resulted in concentrated animal numbers relying on decadent aspen stands. Prescribed fire in aspen provides a significant forage resource to ungulates within 1 to 2 years after burning (Canon et al. 1987). When a stand does burn and sprout suckers, it may be utilized too heavily due to the scarcity of suckers on the landscape. If the suckers are continually over utilized, the stand will eventually disappear from the landscape.

Insects and diseases

Aspen is host to many insects and diseases, but only a few result in significant damage. Western tent caterpillar (*Malacosoma californicum*), found throughout the Intermountain West, can defoliate large acreages of aspen in years when population densities are high. This defoliation can become severe enough to cause tree mortality. Species of boring insects that damage or kill aspen include: poplar borer (*Saperda calcarata*), poplar twig borer (*Saperda moesta*), poplar branch borer (*Oberea schaumii*), poplar butt borer (*Xylotrechus obliteratus*) and bronze poplar borer (*Agrilus liragus*). These borers can cause severe physical damage or mortality to aspen. They also provide openings that allow cankers, fungus, and disease to infect, deform, and kill trees (Jones, Debyle, and Bowers 1985).

Sooty canker (*Cenangium singulare*) is considered the most lethal canker and is a major cause of aspen mortality in the West. Black cankers (*Ceratocystis fimbriata*) are large slow growing cankers that are seldom fatal, but cause considerable deformity. *Cryptosphaeria* is a recently discovered canker that grows rapidly and can kill stems in a few years (Hinds 1985, Shepperd 1986). Shepperd (1986) feels that the most serious cause of mortality in aspen stands is decay. Stems older than 100 years of age have the highest rate of infection. A false tinder fungus that enters through a wound to the sapwood or heartwood can cause this decay. *Phellinus tremulae* is the predominant aspen trunk rot fungus in North America (Hinds 1985).

Summary

There are many more topics and literature on aspen that are not covered in this review. Examples include: genetic diversity, forage quality, water relations, detailed physiology and morphology, silviculture of aspen, harvest methods, aspen wood products and uses, greenhouse methods of regeneration, etc. However the list of literature is a good representation that can be further investigated by individuals seeking specific information.

DATA ANALYSIS

Organization of the data set and analysis procedures

Appendix 3 contains site-specific data for seventy-seven aspen stands visited in 2000 on the Wallowa Mountains Zone, Wallowa-Whitman National Forest. An expansion factor of 14.147 was used to convert plot counts to a per-hectare (ha) basis.[1] Estimated tree ages were based on tree-ring counts from cores. Ages were averaged across stands by structural class[2]. The data set was separated into three groups: "pre-treatment with plot-data" (n=72), "pre-treatment without plot-data" (n=3)[3], and "buck and pole" (n=2)[4].

Descriptive statistics[5] were generated for twenty-five variables, and frequency[6] tables were generated for eight categorical variables[7] for the "pre-treatment with plot-data" group only since the buck and pole group had only 2 entries. S-PLUS 2000 was used for all calculations unless otherwise indicated (MathSoft, 2000).

RESULTS

A. Pre-treatment sites with plot-data, n=72

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[1] One hectare=2.47 acres.

[2] Sub-dominant: trees greater than 2m (6.5ft) tall but not part of the co-dominant canopy; Co-dominant: classed as height of adult aspen; Dominant conifers taller than co-dominant.

[3] Stands 12B, 23A and 23B contain no plot data, but were recorded for inventory purposes only.

[4] Stands 8B-1 and 8A are enclosed by buck and pole fencing which has been in place for about 20 years.

[5] **Mean:** the arithmetic average; **First Quartile:** the observed value for which 25% of the data fall below and 75% fall above when the data are ranked from lowest to highest; **Median**: the observed value for which 50% of the data fall below and 50% fall above when the data are ranked from lowest to highest; **Third Quartile:** the value for which 75% of the data fall below and 25% fall above when the data are ranked from lowest to highest; **Standard Deviation (SD)**: a statistic which measures the spread or variability in the data, i.e. the higher the standard deviation, the more spread out from the mean are the data; **Minimum:** the value of the minimum datum; **Maximum**: the value of the maximum datum.

[6] "Frequency of occurrence" is the number of observations (usually stands) in a given category.

[7] Categorical or qualitative variables are not measurements per se, but classifications into different categories represented by a number code.e.g. hair color, presence/absence, aspen vigor.

Considerable variability exists in the habitat variables for this data set. The ten stem-density measures show extreme ranges [8]of values (see Table 1) and highly skewed[9] frequency distributions (see Appendix 4). With such highly skewed distributions, the mean, or average, is subject to distortion since it is sensitive to extreme values. The value of the mean is pulled in the direction of the tail. For example, the mean number of aspen sprouts is 2171/ha, and the median is 1386/ha. The mean is being "pulled" to the right, in the direction of the tail, (Appendix 4) by the extreme value of 14,712 sprouts/ha. The median, 1st and 3rd quartiles further describe the distribution of the variables and should be consulted in addition to the mean. Either median or mean value is used in the following sections. The reader is encouraged to refer to all 7 statistics as well as the frequency histograms (presented in Appendix 4) for each variable.

The median value for the number of aspen sprouts/saplings was 1,386/ha, (Table 1, Appendix 4). Relative vigor of aspen sprouts/saplings was evaluated using criteria developed by Tatum, see Appendix 2. In 82% of the pre-treatment sites, aspen sprouts/saplings were in the declining to dead or absent conditions. The remaining 18% were in the mixed condition (Table 2). Two measures of height were made for aspen sprouts/saplings: lower and upper ends of their height-range. Mean height for the lower end was 22 cm and for the upper end, 111 cm. Eighty-eight percent of stands showed evidence of historic browse by herbivores to the aspen sprouts/saplings layer (Table 3), while 16% showed evidence of browse in the current year (Table 4). Herbivory might be less earlier in the year, thus the time of year the surveys were conducted might account for the large difference in these results.

Fifty percent of the stands had zero aspen snags and zero conifers, 25% had no aspen down-dead nor an aspen sub-dominant component (Table 1). Relative vigor of adult aspen[10] was evaluated according to Tatum (Appendix 2). Sixty-nine percent of sites were rated in the declining to dead conditions, 29% mixed and 2% stable (Table 5).

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[8] The *range* is the difference between the maximum and minimum measurements of the data set for a variable.

[9] Skewed distributions have long tails in either direction, as opposed to the Normal distribution which is roughly mound-shaped and symmetrical.

[10] The aspen vigor classification system was designed to assess vigor in three different structural classes. In this data set however, vigor was classified into only 2 groups, "sprouts" and "adults". Thus, the authors assume that" sprouts" consisted of the sprouts-saplings layer, and "adults" consisted of the sub and co-dominant layers.

Table 1

Descriptive statistics for 25 habitat variables from the pre-treatment group, n=72

Variable	Sample Size	Mean	Standard Deviation	1st Quartile	Median	3rd Quartile	Minimum	Maximum
# Aspen Sprouts-saplings/ha	72	2170.975	2590.454	452.704	1386.406	2885.988	0	14712.88
# Aspen Sub-dominants/ha	72	514.9901	952.3325	0	169.764	636.615	0	6903.736
# Aspen Co-dominants/ha	72	211.0261	198.0402	67.19825	169.764	282.94	0	1018.584
# Aspen Dominants/ha	72	3.929722	21.9193	0	0	0	0	169.764
# Aspen Standing-dead/ha	72	48.33558	107.2092	0	0	28.294	0	565.88
# Aspen Down-dead/ha	72	47.54964	64.42868	0	21.2205	56.588	0	226.352
# Conifer Sprouts-saplings/ha	72	121.6249	276.813	0	0	169.764	0	1980.58
# Conifer Sub-dominants/ha	72	77.8085	134.1262	0	0	116.7128	0	622.468
# Conifer Co-dominants/ha	72	23.18536	57.49263	0	0	14.147	0	396.116
# Conifer Dominants/ha	72	16.11186	42.2283	0	0	3.53675	0	282.94
Aspen Canopy Cover (%)	72	29.09722	17.4041	15	25.5	37	1	72
Conifer Canopy Cover (%)	72	12.19722	12.37314	1.75	10	18	0	47
Height of Aspen, Sprouts-saplings low end (cm)	65	21.8	28.59644	10	10	20	1	200
Height of Aspen, Sprouts-saplings high end (cm)	65	111.4615	60.74873	60	100	180	30	200
Height of Aspen, Co-dominant (m)	69	16.21739	4.259486	13	16	20	3	24
Height of Conifer, Co-dominant (m)	36	17.16667	4.00357	14	18	20	10	24
Height of Conifer, Dominant (m)	56	25.75	3.1174	25	25	27	18	30
Average Age of Aspen, Sub-dominants	24	44.94444	22.46885	27.5	40	55.79167	18	102
Average Age of Aspen, Co-dominants	29	81.84483	34.17773	66	80	99.5	27.5	147
Average Age of Aspen, Dominants	n/a							
Average Age of Conifer, Sub-dominants	27	39.59259	21.82341	26.66667	31	49	10	91
Average Age of Conifer, Co-dominants	28	68.87202	23.56743	59.25	69	83.75	27.5	119
Average Age of Conifer, Dominants	32	94.46875	40.26853	59.25	90.25	127	25.5	187
Slope Gradient (%)	72	14.02778	13.98286	5	10	20	0	65
Amount of Stand Lost (%)	69	69.18841	20.97637	50	80	85	20	99

Mean aspen canopy cover was greater than that for conifers by approximately 2.5 times, 29% and 12% respectively. Mean heights of the co-dominant layer were essentially the same for aspen and conifer, 16 and 17 meters, respectively. This is not surprising given that co-dominant was defined as "height of adult aspen". The height of the dominant conifer layer averaged 25 meters (Table 1).

Stand-age was calculated from a subset of the 72 stands because aspen trees in the remaining stands were too rotten to be cored and/or aged. Thus, actual stand-age might be older than reported. Average age of the sub-dominant aspen layer was five years older than the corresponding conifer layer, 50 and 45 years, respectively (from n=24 stands). Average ages of the co-dominant layer showed greater differences, 82 years for aspen and 69 years for conifer (from n=29stands). The mean age for the dominant conifer layer was 94 years. Data were not available to compute statistics for the dominant aspen layer.

The median value for the proportion of stand-area lost over time was 80% . Slope gradient averaged 14%. Seventy-five percent of the pre-treatment sites were classified as "upland", 18% as "meadow", 6% as "riparian" and 1% as "seep"(Table 6). Most sites had a flat micro-relief (75%, Table 7), and were located at mid-slope (86%, Table 8).

Table 2

Frequency of occurrence for "Vigor of Aspen Sprouts", pre-treatment group

Category	Frequency
0	8
1	0
2	0
3	13
4	11
5	36
6	4

Table 3

Frequency of occurrence for "Evidence of Historic Browse", pre-treatment group

Category	Frequency
No	8
Yes	56
n/a	8

Table 4
Frequency of occurrence for "Evidence of Current Years' Browse", pre-treatment group

Category	Frequency
No	47
Yes	9
n/a	16

Table 5
Frequency of occurrence for "Vigor of Aspen Adults", pre-treatment group

Category	Frequency
0	0
1	0
2	1
3	21
4	18
5	29
6	3

Table 6
Frequency of occurrence for "Landform", pre-treatment group

Category	Frequency
1	1
2	0
3	4
4	13
5	54

Table 7
Frequency of occurrence for "Micro-Relief", pre-treatment group

Category	Frequency
1	0
2	18
3	53
n/a	1

Table 8
Frequency of occurrence for "Position on Slope", pre-treatment group

Category	Frequency
1	6
2	50
3	2
n/a	14

Table 9
Frequency of occurrence for "Aspect", pre-treatment group

Category	Frequency
E	4
N	8
NW	8
S	10
SE	10
SW	4
W	14
n/a	14

B. Buck & Pole sites, n = 2

No descriptive statistics were generated for this group since only 2 protected sites were available. Table 10 lists the results for 23 habitat variables. Sites WW 8A and WW 8B-1 have been surrounded by buck and pole fencing for approximately 20 years. Neither had high numbers of sprouts (<1850/ha), but the sub-dominant layer in both stands had significantly greater stem-density than the average pre-treatment site (>3200/ha vs 515/ha). Data for aspen sprout and adult vigor is inconsistent with the 2000 summary report (Kautz, 2000). He states "...aspen within the fence were vigorous...", whereas aspen sprouts were rated "absent" for WW 8B-1 and adults were rated as "declining" in WW8A.

Table 10

Values of habitat variables for two sites surrounded with buck and pole fencing

	WW 8A	WW 8B-1
# Aspen Sprouts-saplings/ha	1810.816	226.352
# Aspen Sub-dominants/ha	3282.104	4979.744
# Aspen Co-dominants/ha	42.441	84.882
# Aspen Dominants/ha	0	0
# Aspen Standing-dead/ha	0	0
# Aspen Down-dead/ha	56.588	0
# Conifer Sprouts-saplings/ha	0	70.735
# Conifer Sub-dominants/ha	0	84.882
# Conifer Co-dominants/ha	0	0
# Conifer Dominants/ha	0	0
Aspen Canopy Cover (%)	22	75
Conifer Canopy Cover (%)	0	0
Height of Aspen, Sprouts-saplings, low end (cm)	40	50
Height of Aspen, Sprouts-saplings, high end (cm)	200	150
Height of Aspen, Co-dominant (m)	22	24
Average Age of Aspen, Sub-dominants	46 n=1	
Average Age of Aspen, Co-dominants	121.5 n=2	
Average Age of Conifer, Sub-dominants	40 n=1	31 n=2
Average Age of Conifer, Co-dominants	66 n=1	
Slope Gradient (%)	5	0
Proportion of Stand Lost (%)	30	20
Aspen Vigor, Sprouts-saplings	2	0
Aspen Vigor, Adults	4	1

SUMMARY

A total of 77 aspen sites were sampled on the Wallowa Mountains Zone, Wallowa-Whitman National Forest during the summer of 2000. Seventy-two stands were pre-treatment, 2 were buck and pole and 3 were recorded for inventory purposes only. Results herein should be applied only to the 77 aspen sites actually sampled and not extrapolated to other aspen stands since there was no randomization technique employed in the selection process.

The estimated proportion of stand-area lost over time for pre-treatment sites averaged 80%. Most stands had low numbers of aspen sprouts (<1300/ha) in declining to dead conditions. Stand-age was mature to over-mature (80+ years) for 29 sites from which ages were calculated. Vigor of adult aspen was also in declining to dead condition. Not only were many co- and dominant aspen diseased, numerous sub-dominant trees had heart rot as well (Kautz, 2000). Two sites sampled in 2000 were protected with buck and pole fencing which has been in place approximately 20 years.

Neither had high numbers of sprouts (<1850/ha). However, both stands had substantial sub-dominant layers (>3200/ha) and aspen within the fence were vigorous (Kautz, 2001).

DISCUSSION

Results herein documented stand structure, age, conifer encroachment and historic herbivory for 74 aspen stands on the Wallowa Mountains Zone, Wallowa-Whitman National Forest. These baseline data will further enable land managers to prioritize stands for future treatments.

Aspen is a relatively short-lived tree in the Blue Mountains,100-120 years, (Crowe, 1996) and relies on suckering (sprouting from the roots) to persist. Potential regeneration problems are likely in mature to over-mature stands with fewer than 1235 suckers/ha (Brown, 1996). Given the low numbers of healthy aspen sprouts, elevated stand age and the apparent lack of viable sub-dominants, the majority of the 72 pre-treatment stands are unlikely to persist without treatment. Many more than two treated sites are necessary to make valid comparisons with pre-treatment sites, or to assess the effectiveness of a treatment.

Determining the most efficacious and cost-effective treatment(s) to rejuvenate aspen within the landscape, not just at the individual stand-level, was a primary objective of this project. Typical treatments in the Blue Mountains (separately or in aggregate) include conifer-thinning, removal of mature aspen, and burning, accompanied by fencing. Treatments are generally focused on the aspen stand itself, an appropriate and necessary methodology to ensure survival of individual stands. Long-term, large-scale rejuvenation however, should also involve assessment of surrounding areas where historic land management practices have altered the historic vegetation/forage community.

Appendix 1.

Site #:_____ **Date:**_____

Vigor:_____ Location:_____

Landform:_____ 1 seep, 2 non-seep but sub-drainage, 3 riparian, 4 meadow, 5 upland

Treatment_____

% Lost_____

Paired Plot_____

Density	Sprout/sapling		Sub		Co-dom. Overstory		Dom. Overstory		Total
Aspen live									
Standing dead									
Down dead									
Conifer spp.									
Conifer spp.									

						Total
Aspen Canopy Cover						
Conifer Canopy Cover						

	Co-dom. Overstory	Dominant Overstory
Aspen height	_____	_____
Conifer height	_____	_____

Aspen sprout/sapling height (range) _____ Browsed (y/n) _____current years_____

# of aspen cored _____ Could not core due to rot _____

DBH Aspen	_____	_____	_____	_____	_____
DBH Dominant Conifer	_____	_____	_____	_____	_____
DBH Sub/co-dom. Conifer	_____	_____	_____	_____	_____

Conifers cored inside aspen stand _____ # cored sub_____co_____dom_____

Conifers cored at edge of aspen stand _____ # cored sub_____co_____dom_____

		Cover Class	
Primary Shrub	_____	_____	1 <1 %
Secondary Shrub	_____	_____	2 1-5 %
Primary Grass	_____	_____	3 5-15 %
Secondary Grass	_____	_____	4 15-25 %
Primary Forb	_____	_____	5 25-50 %
Secondary Forb	_____	_____	6 50-75 %
			7 75- 95%
			8 100%

Slope _____

Slope' _____ 1crest 2mid 3toe

Aspect _____

Elevation _____

Micro-relief _____ 1convex 2concave 3flat

COMMENTS:

Appendix 2.

Aspen Stand Vigor Classification

In an attempt to classify stand structures found in various hardwood stands throughout the Districts, Mike Tatum designed the following system. It identifies several characteristics of stands in simple yet reasonably accurate terms:

	"A"	"B"	"C"
Structural Layer:	Understory	Midstory	Overstory
Typical Age:	0-25	25-75	75-125+
Age Class:	Sprouts/Juvenile	Immature/Early Mature	Late/Over Mature
Size Group:	Sprouts/Sapling	Poles/Large	Large+
Vigor Groups:	0 layer absent	0 layer absent	0 layer absent
	1 vigorous	1 vigorous	1 vigorous
	2 stable	2 stable	2 stable
	3 mixed cond.	3 mixed cond.	3 mixed cond.
	4 declining	4 declining	4 declining
	5 decadent	5 decadent	5 decadent
	6 dead	6 dead	6 dead

Each site can be characterized with the use of seven characters to depict the presence and condition of any one layer. These available characters give 343 combinations to accurately describe structure. For example: A stand with a nearly dead understory, a middlestory with some good and some poor condition individuals and an overstory of fair condition would be classified as: "A4B3C2".

Definitions for vigor groups:

0 = **Layer absent** = No individuals of this structure are present, common sense applies: if you have a clump of 3 aspen and there are three sprouts, then this layer does exist, the same three sprouts contained within a 3 acre aspen stand would not count.

1 = **Vigorous** = No evidence of permanent disease (conks), foliage disease may be present but not causing long term damage, bark is healthy (not seriously damaged), evidence shows very good annual leader/height growth, minor browsing/hedging.

2 = **Stable** = The layer appears to be free and clear to grow, only minor stem or leaf disease, browsing or hedging may be checking annual growth, other minor physical damage may have occurred, only occasional cavity excavation. Growth "good-fair".

3 = **Mixed condition** = A significant portion of the individuals in this structural layer meet condition 1 or 2, and a significant portion meet conditions 4-6.

4 = **Declining** = Shortening crown ratio's, lack of or short annual growth, cavity excavators beginning frequent excavations, disease conks present, heavy browsing/hedging with reduced sprouting, suppression or overtopping by other trees, or other physical damage causing serious injury. Occasional dead trees of this layer present. Growth "poor".

5 = **Decadent** = Nearly dead, frost cracks, broken or split tops, major portion of tree dead, many cavities from bird use, typically at least 80-90 years old at minimum. Dead trees common of same age. Growth "stopped".

6 = **Dead** = Dead.

Appendix 3

	Site	Treatment	Position of Site on Slope	Aspect of Site	Micro-relief of Site	Landform	Percentage of Stand Lost	Gradient of Slope (%)	Vigor of Aspen Sprouts
1	WW 10A	Pre-treatment	2	NW	3	5	75	5	3
2	WW 10B	Pre-treatment			3	5		0	0
3	WW 10C	Pre-treatment	2	E	3	5	90	25	3
4	WW 10D	Pre-treatment			3	4	40	0	4
5	WW 11A	Pre-treatment	2	W	3	5	40	15	5
6	WW 12A-1	Pre-treatment	2	E	3	5		45	6
7	WW 12A-2	Pre-treatment	2	E	3	5	90	45	5
8	WW 13	Pre-treatment	2	N	3	5	30	15	5
9	WW 14A	Pre-treatment	2	NW	3	5	80	45	5
10	WW 14B-1	Pre-treatment	2	W	3	5	50	20	3
11	WW 14B-2	Pre-treatment	2	W	3	5	50	25	3
12	WW 15A	Pre-treatment	2	NW	2	5	40	20	5
13	WW 15B	Pre-treatment	2	NW	2	5	40	10	4
14	WW 15C	Pre-treatment	2	W	3	5	90	20	5
15	WW 15D	Pre-treatment	2	NW	3	5	80	15	5
16	WW 15E	Pre-treatment	2	W	2	5	30	25	4
17	WW 15F	Pre-treatment	2	N	2	5	85	20	3
18	WW 15G	Pre-treatment	2	W	2	5	75	10	5
19	WW 15H	Pre-treatment	2	NW	2	5	60	45	4
20	WW 15I	Pre-treatment	2	W	3	5	40	15	3
21	WW 15J	Pre-treatment	2	SW	3	5	75	65	4
22	WW 15K	Pre-treatment	2	W	2	3	95	25	5
23	WW 16A	Pre-treatment	2	W	3	5	60	10	6
24	WW 16B	Pre-treatment	2	N	3	5	70	15	5
25	WW 16C	Pre-treatment	2	W	2	5	50	20	5
26	WW 16D	Pre-treatment	2	N	3	5	50	5	5
27	WW 17A	Pre-treatment	1	SW	3	5	90	5	5
28	WW 17B-1	Pre-treatment	2	S	3	5	80	10	5
29	WW 17B-2	Pre-treatment	2	S	3	5	80	5	5
30	WW 17B-3	Pre-treatment	1	SE	3	5	80	10	5
31	WW 18A	Pre-treatment	2	E	3	5	85	10	5

Site	Vigor of Aspen Adults	Evidence of Historic Browse	Evidence of Current Years' Browse	Percent of Plants Browsed	# Aspen Sprouts on Plot	# Aspen Sprouts per Hectare
WW 10A	4	y	y	25	320	4527
WW 10B	3				0	0
WW 10C	5	y	n		216	3056
WW 10D	3	y	n		20	283
WW 11A	5	y	n		48	679
WW 12A-1	5				0	0
WW 12A-2	5	y	y	50	152	2150
WW 13	2	y	n		0	0
WW 14A	3	y	y	75	172	2433
WW 14B-1	3	y	n		240	3395
WW 14B-2	3	y	n		264	3735
WW 15A	3	n			80	1132
WW 15B	4	n			16	226
WW 15C	4	n			36	509
WW 15D	5	y	n		120	1698
WW 15E	4	y	n		136	1924
WW 15F	3	y	n		248	3508
WW 15G	6				0	0
WW 15H	3	y	n		96	1358
WW 15I	3	y	n		224	3169
WW 15J	3	y	n		60	849
WW 15K	5	n			72	1019
WW 16A	3				0	0
WW 16B	6				0	0
WW 16C	3	y	n		8	113
WW 16D	3	y	n		156	2207
WW 17A	5	y	n		60	849
WW 17B-1	5	y	y	25	576	8149
WW 17B-2	3	y	n		392	5546
WW 17B-3	5	y	n		152	2150
WW 18A	5	y	n		64	905

Site	# Aspen Sub-dominants per Hectare	# Aspen Co-dominants on Plot	# Aspen Co-dominants per Hectare	# Aspen Dominants on Plot	# Aspen Dominants per Hectare
WW 10A	113	4	57	0	0
WW 10B	2037	12	170	0	0
WW 10C	57	4	57	0	0
WW 10D	42	58	821	0	0
WW 11A	141	15	212	0	0
WW 12A-1	1019	44	622	12	170
WW 12A-2	42	0	0	0	0
WW 13	6904	0	0	0	0
WW 14A	509	20	283	0	0
WW 14B-1	1811	0	0	0	0
WW 14B-2	396	24	340	0	0
WW 15A	325	5	71	0	0
WW 15B	85	7	99	0	0
WW 15C	170	16	226	0	0
WW 15D	0	16	226	0	0
WW 15E	934	27	382	0	0
WW 15F	905	24	340	0	0
WW 15G	0	4	57	0	0
WW 15H	679	20	283	0	0
WW 15I	453	72	1019	0	0
WW 15J	453	24	340	0	0
WW 15K	453	4	57	0	0
WW 16A	0	28	396	0	0
WW 16B	0	24	340	0	0
WW 16C	2490	32	453	0	0
WW 16D	57	9	127	0	0
WW 17A	0	16	226	0	0
WW 17B-1	0	2	28	0	0
WW 17B-2	509	4	57	0	0
WW 17B-3	57	20	283	0	0
WW 18A	453	8	113	0	0

Site	# Aspen Standing-dead on Plot	# Aspen Standing-dead per Hectare	# Aspen Down-dead on Plot	# Aspen Down-dead per Hectare	# Conifer Saplings on Plot	# Conifer Saplings per Hectare
WW 10A	1	14	0	0	0	0
WW 10B	0	0	0	0	0	0
WW 10C	0	0	0	0	0	0
WW 10D	8	113	1	14	0	0
WW 11A	0	0	1	14	0	0
WW 12A-1	1	14	16	226	0	0
WW 12A-2	0	0	0	0	0	0
WW 13	0	0	0	0	12	170
WW 14A	12	170	16	226	0	0
WW 14B-1	0	0	0	0	0	0
WW 14B-2	0	0	16	226	0	0
WW 15A	0	0	0	0	4	57
WW 15B	0	0	8	113	2	28
WW 15C	0	0	0	0	4	57
WW 15D	0	0	16	226	0	0
WW 15E	1	14	3	42	0	0
WW 15F	12	170	0	0	0	0
WW 15G	2	28	7	99	0	0
WW 15H	0	0	16	226	0	0
WW 15I	12	170	8	113	0	0
WW 15J	0	0	4	57	0	0
WW 15K	0	0	4	57	0	0
WW 16A	0	0	0	0	0	0
WW 16B	16	226	12	170	0	0
WW 16C	4	57	8	113	4	57
WW 16D	0	0	0	0	0	0
WW 17A	0	0	4	57	12	170
WW 17B-1	0	0	0	0	8	113
WW 17B-2	0	0	0	0	24	340
WW 17B-3	0	0	0	0	16	226
WW 18A	0	0	0	0	40	566

Site	# Conifer Sub-dominants on Plot	# Conifer Sub-dominants per Hectare	# Conifer Co-dominants on Plot	# Conifer Co-dominants per Hectare	# Conifer Dominants on Plot
WW 10A	0	0	10	141	0
WW 10B	0	0	0	0	0
WW 10C	0	0	4	57	0
WW 10D	0	0	0	0	0
WW 11A	0	0	2	28	1
WW 12A-1	0	0	0	0	0
WW 12A-2	0	0	0	0	0
WW 13	2	28	0	0	0
WW 14A	0	0	0	0	0
WW 14B-1	0	0	0	0	0
WW 14B-2	4	57	0	0	0
WW 15A	4	57	0	0	4
WW 15B	5	71	4	57	0
WW 15C	0	0	0	0	4
WW 15D	0	0	0	0	0
WW 15E	0	0	1	14	0
WW 15F	0	0	0	0	0
WW 15G	0	0	0	0	0
WW 15H	0	0	0	0	0
WW 15I	0	0	0	0	0
WW 15J	0	0	0	0	0
WW 15K	0	0	0	0	0
WW 16A	0	0	0	0	0
WW 16B	0	0	0	0	0
WW 16C	0	0	0	0	0
WW 16D	0	0	0	0	0
WW 17A	32	453	8	113	0
WW 17B-1	12	170	4	57	0
WW 17B-2	4	57	28	396	0
WW 17B-3	20	283	0	0	0
WW 18A	4	57	4	57	4

Site	# Conifer Dominants per Hectare	Aspen Canopy Cover (%)	Conifer Canopy Cover (%)	Height of Aspen Co-dominant (m)	Height of Aspen Sprouts low end (cm)	Height of Aspen Sprouts upper end (cm)
WW 10A	0	20	17	14	10	100
WW 10B	0	64	0	22		
WW 10C	0	8	27	10	10	100
WW 10D	0	69	0	14	10	100
WW 11A	14	36	16	10	10	40
WW 12A-1	0	65	0.4	10		
WW 12A-2	0	1	23		20	100
WW 13	0	3	4	3	10	200
WW 14A	0	30	0	12	20	200
WW 14B-1	0	26	0		10	200
WW 14B-2	0	54	0	12	10	200
WW 15A	57	36	18	18	10	30
WW 15B	0	33	3	24	10	30
WW 15C	57	16	24	16	10	60
WW 15D	0	35	0.6	16	10	200
WW 15E	0	42	2	16	10	100
WW 15F	0	40	0.4	20	30	150
WW 15G	0	12	0	20		
WW 15H	0	49	0	16	10	150
WW 15I	0	72	0	12	10	200
WW 15J	0	35	12	16	1	200
WW 15K	0	29	0	16	10	60
WW 16A	0	43	0	13		
WW 16B	0	32	16	18		
WW 16C	0	70	1	18	35	35
WW 16D	0	50	11	17	20	200
WW 17A	0	15	22	16	10	40
WW 17B-1	0	13	14	12	10	150
WW 17B-2	0	13	24	14	10	80
WW 17B-3	0	21	5	16	10	80
WW 18A	57	20	21	10	30	200

Site	Height of Conifer Co-dominant (m)	Height of Conifer Dominant (m)	Average Age of Sub-dominant Aspen	Sample Size	Average Age of Co-dominant Aspen	Sample Size
WW 10A	14	20	30	1	n/a	
WW 10B		27	48.5	2	n/a	
WW 10C	10	25	n/a		n/a	
WW 10D		18	n/a		66	4
WW 11A	10	22	n/a		28	3
WW 12A-1		30	n/a		36	1
WW 12A-2		30	n/a		n/a	
WW 13		22	n/a		n/a	
WW 14A			28	1	74	1
WW 14B-1		20	46	2	n/a	
WW 14B-2			n/a		n/a	
WW 15A	18	30	39	1	147	1
WW 15B	24		n/a		n/a	
WW 15C		30	56.66666667	3	n/a	
WW 15D		25	n/a		111	1
WW 15E	16	25	n/a		69.5	2
WW 15F	20		n/a		93.5	2
WW 15G			n/a		n/a	
WW 15H		22	n/a		75	2
WW 15I			n/a		44.5	2
WW 15J		25	22	1	n/a	
WW 15K			23	2	n/a	
WW 16A	13	23	n/a		n/a	
WW 16B	18	30	98	1	n/a	
WW 16C	18	30	n/a		n/a	
WW 16D		25	n/a		93.33333333	3
WW 17A	16	24	n/a		138	1
WW 17B-1	12	18	n/a		n/a	
WW 17B-2	14		n/a		n/a	
WW 17B-3			n/a		n/a	
WW 18A	10	27	n/a		95	1

Site	Average Age of Dominant Aspen	Sample Size	Average Age of Conifer Sub-dominant	Sample Size	Average Age of Conifer Co-dominant	Sample Size
WW 10A	n/a		34	1		
WW 10B	n/a					
WW 10C	n/a				93	1
WW 10D	n/a					
WW 11A	n/a				27.5	2
WW 12A-1	n/a					
WW 12A-2	n/a					
WW 13	n/a					
WW 14A	n/a				57	1
WW 14B-1	n/a		38	1		
WW 14B-2	n/a					
WW 15A	n/a				64	1
WW 15B	n/a					
WW 15C	n/a					
WW 15D	n/a				106	1
WW 15E	n/a				65	1
WW 15F	n/a				95	1
WW 15G	n/a					
WW 15H	n/a					
WW 15I	n/a		42.5	2	68	1
WW 15J	n/a					
WW 15K	n/a		28	1		
WW 16A	n/a					
WW 16B	n/a					
WW 16C	n/a		24	1	89	2
WW 16D	n/a					
WW 17A	n/a				72.5	2
WW 17B-1	n/a		27	1		
WW 17B-2	n/a					
WW 17B-3	n/a					
WW 18A	n/a		31	1		

Site	Average Age of Conifer Dominant	Sample Size	Comments
WW 10A			
WW 10B	100	2	
WW 10C			
WW 10D			
WW 11A			
WW 12A-1	135	2	
WW 12A-2			
WW 13	57	1	Recommend cutting prostrate aspen to determine age.
WW 14A	32	2	Intense impact on aspen by cattle browsing and trampling. Root structure prominently exposed throughout site. Many aspen prostrate in appearance.
WW 14B-1	48	2	Wide variation and segragation of aspen growth forms on this site (sub-dom, co-dom, prostrate, suckers).
WW 14B-2			
WW 15A			
WW 15B			
WW 15C	142.5	2	Fire scar in bottom of larch west of stand.
WW 15D	89	1	
WW 15E			Co-dom aspen on peripheal; prostrate in the center.
WW 15F			Mentionable number of dead fallen aspen. Almost half the number of standing.
WW 15G	187	1	Mentionable number of dead fallen aspen.
WW 15H			
WW 15I			Sub-dom asp show signs of rot.
WW 15J			
WW 15K			Sub-dom asp show signs of rot.
WW 16A			On private land, only 50 m across property line. Many of the aspen cored were rotten. Cattle bedding in vicinity.
WW 16B			
WW 16C	25.5	2	
WW 16D			
WW 17A			Only 4 co-dom aspen on the site.
WW 17B-1	131	1	Aspen stands scattered in clusters over the area.
WW 17B-2			
WW 17B-3			
WW 18A			Sub-dom asp show signs of rot.

	Site	Treatment	Position of Site on Slope	Aspect of Site	Micro-relief of Site	Landform	Percentage of Stand Lost	Gradient of Slope (%)	Vigor of Aspen Sprouts
32	WW 18B	Pre-treatment	2	S	3	5	90	20	5
33	WW 18C	Pre-treatment	2	S	3	5	95	25	5
34	WW 18D	Pre-treatment	2	S	2	5	85	45	0
35	WW 18E	Pre-treatment	2	SE	2	5	80	10	3
36	WW 18F	Pre-treatment	1	SE	3	5	85	5	4
37	WW 18G	Pre-treatment	1	S	3	5	80	10	0
38	WW 18H	Pre-treatment	3	SW	3	5	90	15	5
39	WW 19A	Pre-treatment	1	S	2	4	80	5	5
40	WW 19B	Pre-treatment	2	N	3	5		20	5
41	WW 19C	Pre-treatment	2	SE	2	3	95	15	5
42	WW 19D	Pre-treatment	1	SE	2	5	85	25	0
43	WW 19E	Pre-treatment	2	SE	3	3	50	50	5
44	WW 20	Pre-treatment	3	N	3	3	95	5	5
45	WW 21	Pre-treatment	2	W	3	5	80	10	3
46	WW 26A-1	Pre-treatment	2	S	3	5	99	5	6
47	WW 26A-2	Pre-treatment	2	SE	3	1	70	5	5
48	WW 26B	Pre-treatment	2	S	3	5	50	5	5
49	WW 26C	Pre-treatment	2	SE	3	5	85	5	5
50	WW 27A	Pre-treatment	2	NW	2	5	90	20	5
51	WW 27B	Pre-treatment	2	W	2	5	90	15	0
52	WW 27C	Pre-treatment	2	W	2	5	85	10	5
53	WW 27D	Pre-treatment			3	5	90	0	5
54	WW 28	Pre-treatment			3	4	40	0	3
55	WW 29A	Pre-treatment	2	SE	2	5	60	10	3
56	WW 29B	Pre-treatment	2	N	3	5	90	20	0
57	WW 29C	Pre-treatment			2	5	50	0	5
58	WW 30A	Pre-treatment	2	SW	3	4	85	10	0
59	WW 30B	Pre-treatment	2	S	3	5	90	20	4
60	WW 30C	Pre-treatment	2	SE	3	4	50	5	0
61	WW 31A	Pre-treatment	2	NW	3	5	25	5	5

Site	Vigor of Aspen Adults	Evidence of Historic Browse	Evidence of Current Years' Browse	Percent of Plants Browsed	# Aspen Sprouts on Plot	# Aspen Sprouts per Hectare	# Aspen Sub-dominants on Plot
WW 18B	5	y	n		188	2660	0
WW 18C	5	y	n		180	2546	4
WW 18D	4	y	n		16	226	24
WW 18E	5	y	n		200	2829	0
WW 18F	5	y	n		104	1471	0
WW 18G	4	y	n		20	283	0
WW 18H	5	y	n		80	1132	0
WW 19A	5	y	n		100	1415	16
WW 19B	5	y	n		136	1924	0
WW 19C	5	y	n		168	2377	0
WW 19D	4	y	n		0	0	4
WW 19E	3	y	n		88	1245	21
WW 20	5	y	n		72	1019	0
WW 21	4	y	n		74	1047	12
WW 26A-1	6				4	57	8
WW 26A-2	4	n			20	283	48
WW 26B	3	n			320	4527	76
WW 26C	5	y	n		60	849	0
WW 27A	5	y	n		148	2094	12
WW 27B	5				0	0	0
WW 27C	4	y	n		32	453	7
WW 27D	5	y	y	25	48	679	0
WW 28	4	y	n		476	6734	0
WW 29A	5	y	n		44	622	144
WW 29B	5	n			32	453	0
WW 29C	3	y	n		344	4867	68
WW 30A	4	y	n		32	453	48
WW 30B	4	y	n		48	679	68
WW 30C	3	y	n		24	340	127
WW 31A	4	y	n		160	2264	102

Site	# Aspen Sub-dominants per Hectare	# Aspen Co-dominants on Plot	# Aspen Co-dominants per Hectare	# Aspen Dominants on Plot	# Aspen Dominants per Hectare
WW 18B	0	3	42	0	0
WW 18C	57	16	226	4	57
WW 18D	340	60	849	0	0
WW 18E	0	8	113	0	0
WW 18F	0	8	113	0	0
WW 18G	0	12	170	0	0
WW 18H	0	6	85	0	0
WW 19A	226	8	113	0	0
WW 19B	0	16	226	0	0
WW 19C	0	8	113	0	0
WW 19D	57	16	226	0	0
WW 19E	297	6	85	0	0
WW 20	0	8	113	0	0
WW 21	170	5	71	0	0
WW 26A-1	113	0	0	0	0
WW 26A-2	679	16	226	0	0
WW 26B	1075	18	255	0	0
WW 26C	0	20	283	0	0
WW 27A	170	32	453	0	0
WW 27B	0	20	283	0	0
WW 27C	99	13	184	0	0
WW 27D	0	8	113	0	0
WW 28	0	36	509	0	0
WW 29A	2037	8	113	0	0
WW 29B	0	28	396	0	0
WW 29C	962	24	340	0	0
WW 30A	679	12	170	4	57
WW 30B	962	4	57	0	0
WW 30C	1797	3	42	0	0
WW 31A	1443	13	184	0	0

Site	# Aspen Standing-dead on Plot	# Aspen Standing-dead per Hectare	# Aspen Down-dead on Plot	# Aspen Down-dead per Hectare	# Conifer Saplings on Plot	# Conifer Saplings per Hectare
WW 18B	0	0	4	57	24	340
WW 18C	0	0	0	0	4	57
WW 18D	0	0	4	57	12	170
WW 18E	0	0	0	0	0	0
WW 18F	0	0	0	0	28	396
WW 18G	8	113	4	57	140	1981
WW 18H	1	14	1	14	41	580
WW 19A	0	0	0	0	0	0
WW 19B	0	0	4	57	0	0
WW 19C	0	0	3	42	2	28
WW 19D	4	57	8	113	0	0
WW 19E	0	0	6	85	0	0
WW 20	0	0	0	0	16	226
WW 21	0	0	1	14	12	170
WW 26A-1	40	566	4	57	0	0
WW 26A-2	4	57	0	0	0	0
WW 26B	0	0	1	14	0	0
WW 26C	0	0	0	0	0	0
WW 27A	0	0	0	0	24	340
WW 27B	0	0	12	170	0	0
WW 27C	2	28	6	85	0	0
WW 27D	0	0	4	57	0	0
WW 28	12	170	4	57	20	283
WW 29A	12	170	8	113	0	0
WW 29B	16	226	0	0	60	849
WW 29C	36	509	0	0	8	113
WW 30A	0	0	0	0	0	0
WW 30B	0	0	0	0	16	226
WW 30C	0	0	0	0	7	99
WW 31A	0	0	0	0	0	0

Site	# Conifer Sub-dominants on Plot	# Conifer Sub-dominants per Hectare	# Conifer Co-dominants on Plot	# Conifer Co-dominants per Hectare	# Conifer Dominants on Plot
WW 18B	0	0	0	0	8
WW 18C	0	0	0	0	0
WW 18D	4	57	4	57	0
WW 18E	0	0	0	0	0
WW 18F	4	57	0	0	4
WW 18G	24	340	12	170	20
WW 18H	11	156	0	0	0
WW 19A	0	0	0	0	0
WW 19B	0	0	0	0	0
WW 19C	10	141	0	0	0
WW 19D	0	0	0	0	0
WW 19E	0	0	0	0	0
WW 20	20	283	0	0	0
WW 21	3	42	3	42	8
WW 26A-1	0	0	0	0	0
WW 26A-2	0	0	0	0	0
WW 26B	1	14	0	0	1
WW 26C	0	0	0	0	8
WW 27A	16	226	0	0	0
WW 27B	0	0	0	0	0
WW 27C	0	0	1	14	1
WW 27D	0	0	0	0	4
WW 28	12	170	8	113	0
WW 29A	8	113	0	0	4
WW 29B	44	622	0	0	0
WW 29C	12	170	0	0	0
WW 30A	0	0	0	0	0
WW 30B	44	622	0	0	0
WW 30C	3	42	0	0	0
WW 31A	0	0	0	0	0

Site	# Conifer Dominants per Hectare	Aspen Canopy Cover (%)	Conifer Canopy Cover (%)	Height of Aspen Co-dominant (m)	Height of Aspen Sprouts low end (cm)	Height of Aspen Sprouts upper end (cm)
WW 18B	113	9	47	12	10	60
WW 18C	0	23	7	12	10	60
WW 18D	0	34	14	20	30	60
WW 18E	0	14	3	14	30	120
WW 18F	57	11	44	14	30	70
WW 18G	283	25	37	20	10	80
WW 18H	0	15	7	20	10	100
WW 19A	0	33	8	20	30	70
WW 19B	0	33	4	12	50	150
WW 19C	0	22	10	22	30	100
WW 19D	0	13	7	16	80	80
WW 19E	0	34	0	24	1	180
WW 20	0	12	23	21	10	50
WW 21	113	13	45	14	10	40
WW 26A-1	0	0.4	10		30	30
WW 26A-2	0	32	0	12	20	40
WW 26B	14	45	4	16	10	40
WW 26C	113	18	35	9	10	40
WW 27A	0	20	5	16	10	100
WW 27B	0	29	7	20		
WW 27C	14	11	23	20	20	200
WW 27D	57	17	25	12	10	50
WW 28	0	24	13	14	40	120
WW 29A	57	41	9	12	60	200
WW 29B	0	23	10	14	20	40
WW 29C	0	52	4	16	10	100
WW 30A	0	30	0.8	14	60	200
WW 30B	0	17	15	22	200	200
WW 30C	0	69	0	24	100	100
WW 31A	0	46	3	12	10	200

Site	Height of Conifer Co-dominant (m)	Height of Conifer Dominant (m)	Average Age of Sub-dominant Aspen	Sample Size	Average Age of Co-dominant Aspen	Sample Size
WW 18B		25	n/a		n/a	
WW 18C		27	55.5	2	n/a	
WW 18D	20	27	n/a		n/a	
WW 18E		25	n/a		66	1
WW 18F	14	25	n/a		n/a	
WW 18G	20	25	n/a		97	4
WW 18H	20	25	102	1	99.5	2
WW 19A	20	24	69	1	87	1
WW 19B	12	25	n/a		74	1
WW 19C	22	25	n/a		n/a	
WW 19D	16	30	n/a		n/a	
WW 19E			45	1	n/a	
WW 20	21		40	1	131	1
WW 21	14	30	67	1	n/a	
WW 26A-1		25	n/a		n/a	
WW 26A-2			18	1	34	1
WW 26B		25	33	3	27.5	2
WW 26C		30	n/a		n/a	
WW 27A		25	n/a		n/a	
WW 27B		27	n/a		n/a	
WW 27C		27	n/a		80	1
WW 27D		27	n/a		113	1
WW 28	14		44	1	n/a	
WW 29A		25	38	2	41	2
WW 29B	14	22	n/a		39.5	2
WW 29C	16	27	40	1	99.5	2
WW 30A			21	1	n/a	
WW 30B		27	n/a		n/a	
WW 30C	24		n/a		n/a	
WW 31A		24	64	1	n/a	

Site	Average Age of Dominant Aspen	Sample Size	Average Age of Conifer Sub-dominant	Sample Size	Average Age of Conifer Co-dominant	Sample Size
WW 18B	n/a					
WW 18C	n/a		67	1		
WW 18D	n/a				70.66666667	3
WW 18E	n/a					
WW 18F	n/a		72	1	61	1
WW 18G	n/a		91	1		
WW 18H	n/a				79	1
WW 19A	n/a					
WW 19B	n/a		78.33333333	3	74.75	4
WW 19C	n/a					
WW 19D	n/a					
WW 19E	n/a				43	1
WW 20	n/a		55	3	62	1
WW 21	n/a				78	1
WW 26A-1	n/a				82	1
WW 26A-2	n/a		28	1		
WW 26B	n/a		30	2	45	1
WW 26C	n/a					
WW 27A	n/a				27.66666667	3
WW 27B	n/a					
WW 27C	n/a		84	1	91	2
WW 27D	n/a					
WW 28	n/a		50	1		
WW 29A	98	1			38	1
WW 29B	n/a				29	2
WW 29C	n/a		40	2	119	2
WW 30A	n/a		15	1		
WW 30B	n/a		13.66666667	3		
WW 30C	n/a		21.66666667	3		
WW 31A	n/a					

Site	Average Age of Conifer Dominant	Sample Size	Comments
WW 18B	89	1	Insect defoliation prominent.
WW 18C	91	3	Hillside scattered with patches of aspen.
WW 18D	52.5	2	
WW 18E	84	2	
WW 18F	117.6666667	3	
WW 18G	102	1	Site would highly benefit from cutting and fencing.
WW 18H			Site would highly benefit from cutting and fencing. Sub-dom aspen are dead or dying.
WW 19A			Located in marsh.
WW 19B	175	1	Ground cover approximately 1m high. Sub-dom asp show signs of rot.
WW 19C			Ground cover approximately 1.5m high. Aspen scattered throughout drainage.
WW 19D			Very few suckers.
WW 19E			Ground cover approximately 1.75m high.
WW 20			Suckers only present on old FS road 099.
WW 21	127	2	Transect most of aspen stand.
WW 26A-1	94	1	Most of sub-dom aspen are dead.
WW 26A-2			Watering trough in close proximity. Bedding grounds for cattle. Aspen beginning to rot.
WW 26B	112.3333333	3	
WW 26C	55	1	
WW 27A	138	2	
WW 27B	127	2	Co-dom aspen beginning to rot.
WW 27C	90	2	
WW 27D	88	1	Aspen stands scattered in clusters over the area.
WW 28			Would respond well to management practices.
WW 29A	60	1	Dom aspen are contained within the stand. Dom aspen do not appear throughout the site. Sub-dom aspen are mostly rotten.
WW 29B	39	2	
WW 29C			
WW 30A			Ground cover is approximately 1m high. Sub-dom aspen beginning to rot.
WW 30B			Sub-dom asp show signs of rot.
WW 30C			Ground cover 1.5 to 2m high. Most of the sub-dom aspen are rotten.
WW 31A			Leaf rot and conks noticeable on many aspen.

	Site	Treatment	Position of Site on Slope	Aspect of Site	Micro-relief of Site	Landform	Percentage of Stand Lost	Gradient of Slope (%)	Vigor of Aspen Sprouts
62	WW 31B	Pre-treatment	2	W	3	5	20	5	5
63	WW 6A	Pre-treatment	2	N	3	5	80	10	5
64	WW 6B	Pre-treatment			3	4	85	0	4
65	WW 7A	Pre-treatment			3	4	40	0	3
66	WW 7B	Pre-treatment				4	80	0	6
67	WW 8B-2	Pre-treatment			3	4	60	0	4
68	WW 8C	Pre-treatment			3	4	60	0	3
69	WW 8D	Pre-treatment			3	4	60	0	4
70	WW 9A	Pre-treatment			3	4	50	0	5
71	WW 9B	Pre-treatment			3	4	50	0	4
72	WW 9C	Pre-treatment			3	5	50	0	3
73	WW 12B	Pre-treatment	2	E	2	5	90	60	0
74	WW 23A	Pre-treatment	2	SE	3	5	30	60	5
75	WW 23B	Pre-treatment	2	W	3	5	20	45	5
76	WW 8A	Buck & pole(2m)	2	W	3	4	30	5	2
77	WW 8B-1	Buck & pole(2m)			3	4	20	0	0

Site	Vigor of Aspen Adults	Evidence of Historic Browse	Evidence of Current Years' Browse	Percent of Plants Browsed	# Aspen Sprouts on Plot	# Aspen Sprouts per Hectare	# Aspen Sub-dominants on Plot
WW 31B	3	y	y	25	128	1811	16
WW 6A	4	y	y	50	304	4301	10
WW 6B	4	n			216	3056	6
WW 7A	3	y	n		272	3848	30
WW 7B	5				0	0	8
WW 8B-2	5	y	y	25	1040	14713	44
WW 8C	5	y	y	25	616	8715	7
WW 8D	4	y	n		304	4301	97
WW 9A	4	y	n		127	1797	41
WW 9B	5	y	n		200	2829	32
WW 9C	3	y	n		696	9846	50
WW 12B	5						
WW 23A	4	y	n				
WW 23B	1	n					
WW 8A	4	n	n		128	1811	232
WW 8B-1	1	n	n		16	226	352

Site	# Aspen Sub-dominants per Hectare	# Aspen Co-dominants on Plot	# Aspen Co-dominants per Hectare	# Aspen Dominants on Plot	# Aspen Dominants per Hectare
WW 31B	226	17	240	0	0
WW 6A	141	6	85	0	0
WW 6B	85	12	170	0	0
WW 7A	424	6	85	0	0
WW 7B	113	24	340	0	0
WW 8B-2	622	3	42	0	0
WW 8C	99	3	42	0	0
WW 8D	1372	14	198	0	0
WW 9A	580	3	42	0	0
WW 9B	453	4	57	0	0
WW 9C	707	4	57	0	0
WW 12B					
WW 23A					
WW 23B					
WW 8A	3282	3	42	0	0
WW 8B-1	4980	6	85	0	0

Site	# Aspen Standing-dead on Plot	# Aspen Standing-dead per Hectare	# Aspen Down-dead on Plot	# Aspen Down-dead per Hectare	# Conifer Saplings on Plot	# Conifer Saplings per Hectare
WW 31B	0	0	4	57	0	0
WW 6A	0	0	2	28	1	14
WW 6B	17	240	4	57	0	0
WW 7A	0	0	3	42	28	396
WW 7B	4	57	4	57	12	170
WW 8B-2	0	0	4	57	4	57
WW 8C	0	0	0	0	23	325
WW 8D	2	28	2	28	0	0
WW 9A	0	0	0	0	4	57
WW 9B	2	28	2	28	5	71
WW 9C	17	240	3	42	2	28
WW 12B						
WW 23A						
WW 23B						
WW 8A	0	0	4	57	0	0
WW 8B-1	0	0	0	0	5	71

Site	# Conifer Sub-dominants on Plot	# Conifer Sub-dominants per Hectare	# Conifer Co-dominants on Plot	# Conifer Co-dominants per Hectare	# Conifer Dominants on Plot
WW 31B	1	14	0	0	1
WW 6A	2	28	6	85	0
WW 6B	4	57	4	57	0
WW 7A	15	212	6	85	0
WW 7B	21	297	4	57	0
WW 8B-2	9	127	0	0	1
WW 8C	11	156	1	14	0
WW 8D	4	57	3	42	0
WW 9A	4	57	0	0	2
WW 9B	13	184	0	0	2
WW 9C	9	127	1	14	5
WW 12B					
WW 23A					
WW 23B					
WW 8A	0	0	0	0	0
WW 8B-1	6	85	0	0	0

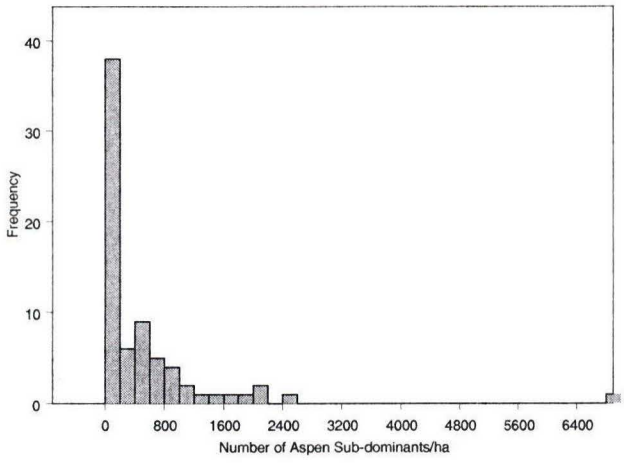
Site	# Conifer Dominants per Hectare	Aspen Canopy Cover (%)	Conifer Canopy Cover (%)	Height of Aspen Co-dominant (m)	Height of Aspen Sprouts low end (cm)	Height of Aspen Sprouts upper end (cm)
WW 31B	14	28	14	18	10	100
WW 6A	0	14	39	20	10	100
WW 6B	0	45	13	22	10	40
WW 7A	0	24	17	20	20	200
WW 7B	0	30	40	24		
WW 8B-2	14	19	10	20	10	70
WW 8C	0	24	18	18	10	100
WW 8D	0	49	6	16	10	100
WW 9A	28	25	10	20	10	100
WW 9B	28	5	10	16	20	200
WW 9C	71	11	20	20	10	150
WW 12B						
WW 23A				8	1	200
WW 23B				8		
WW 8A	0	22	0	22	40	200
WW 8B-1	0	75	0	24	50	150

Site	Height of Conifer Co-dominant (m)	Height of Conifer Dominant (m)	Average Age of Sub-dominant Aspen	Sample Size	Average Age of Co-dominant Aspen	Sample Size
WW 31B	18	26	n/a		n/a	
WW 6A	20	30	n/a		n/a	
WW 6B	22		n/a		119	2
WW 7A	20	25	n/a		n/a	
WW 7B	24	27	n/a		128.6666667	3
WW 8B-2		30	26	1	n/a	
WW 8C	18	30	n/a		n/a	
WW 8D	16	25	n/a		n/a	
WW 9A		25	n/a		n/a	
WW 9B		22	25	1	n/a	
WW 9C	20	30	n/a		66	1
WW 12B						
WW 23A						
WW 23B						
WW 8A			46	1	121.5	
WW 8B-1	24					

Site	Average Age of Dominant Aspen	Sample Size	Average Age of Conifer Sub-dominant	Sample Size	Average Age of Conifer Co-dominant	Sample Size
WW 31B	n/a		29	1	99.33333333	3
WW 6A	n/a					
WW 6B	n/a		10	1		
WW 7A	n/a		33.5	2		
WW 7B	n/a					
WW 8B-2	n/a		26.33333333	3		
WW 8C	n/a		25	1	70	1
WW 8D	n/a		48	1		
WW 9A	n/a				60	1
WW 9B	n/a					
WW 9C	n/a		27	1	62	1
WW 12B						
WW 23A						
WW 23B						
WW 8A			40	1	66	1
WW 8B-1			31	2		

Site	Average Age of Conifer Dominant	Sample Size	Comments
WW 31B			
WW 6A			Co-dom present in small clumps. Sub-dom represent variability across the site.
WW 6B			
WW 7A			Heavy cattle movement in area; would recommend restricting cattle.
WW 7B	49	1	
WW 8B-2	90.5	2	Paired with WW 8B-2. Outside the enclosure.
WW 8C			
WW 8D			Extensive tree rubbing
WW 9A	83	1	Site is very patchy. Was able to account for most of the variability within the transect.
WW 9B	71	1	
WW 9C	141	1	
WW 12B			Hawthorne too thick to access site.
WW 23A			Too steep and rocky to traverse. Unable to lay transect.
WW 23B			Ribes too thick to access and steep. Aspen appears vigorous.
WW 8A			One of the few enclosures on Wallowa-Whitman NF. Abundance of sub-dom aspen approximately 3 m tall.
WW 8B-1			Paired with WW 8B-1.

Appendix 4


Frequency
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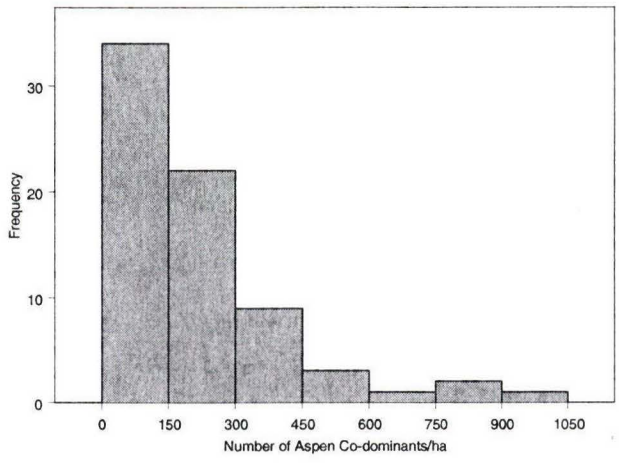
30
40
0
800
1600
2400
3200
4000
4800
5600
6400
Number of Aspen Sub-dominants/ha


Frequency
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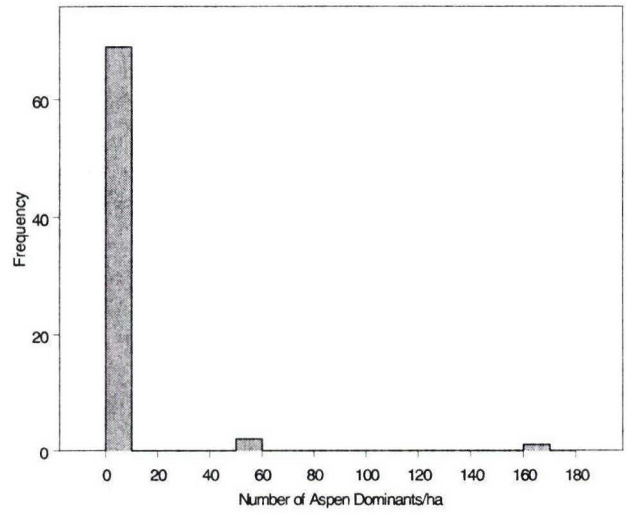
30
0
150
300
450
600
750
900
1050
Number of Aspen Co-dominants/ha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60
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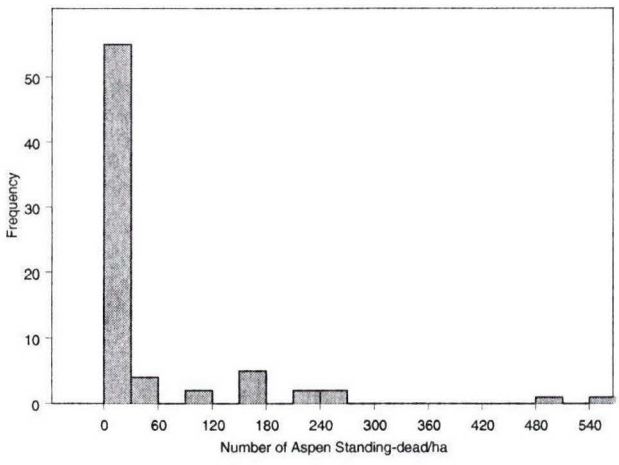
20
40
60
80
100
120
140
160
180
Number of Aspen Dominants/ha


Frequency
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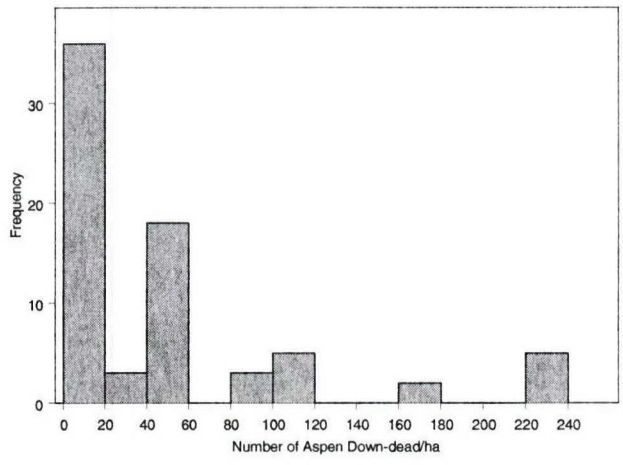
30
40
50
0
60
120
180
240
300
360
420
480
540
Number of Aspen Standing-dead/ha


Frequency
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20
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60
80
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120
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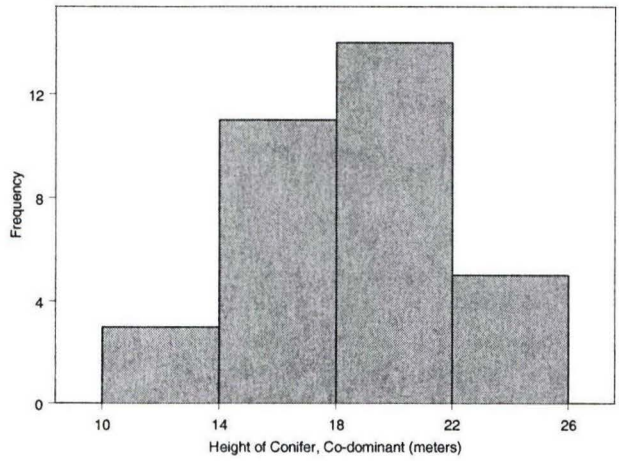
200
220
240
Number of Aspen Down-dead/ha


Frequency
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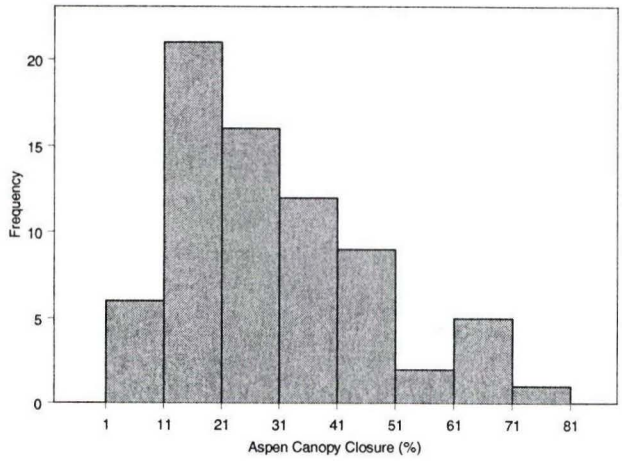
8
12
10
14
18
22
26
Height of Conifer, Co-dominant (meters)


Frequency
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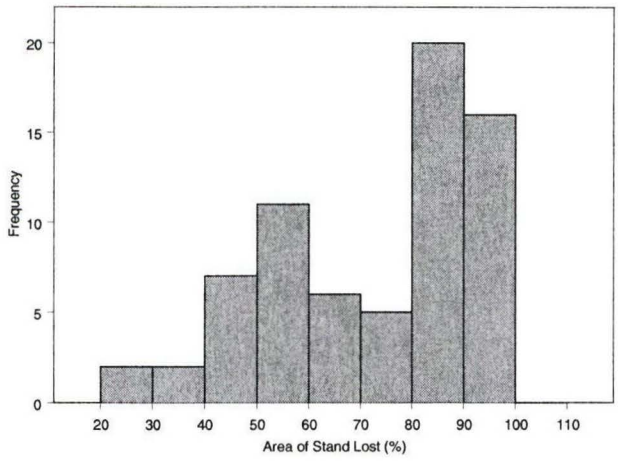
10
15
20
1
11
21
31
41
51
61
71
81
Aspen Canopy Closure (%)


Frequency
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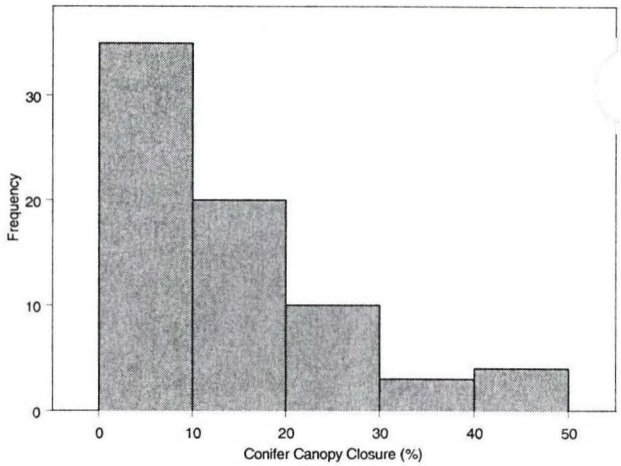
5
10
15
20
20
30
40
50
60
70
80
90
100
110
Area of Stand Lost (%)


Frequency
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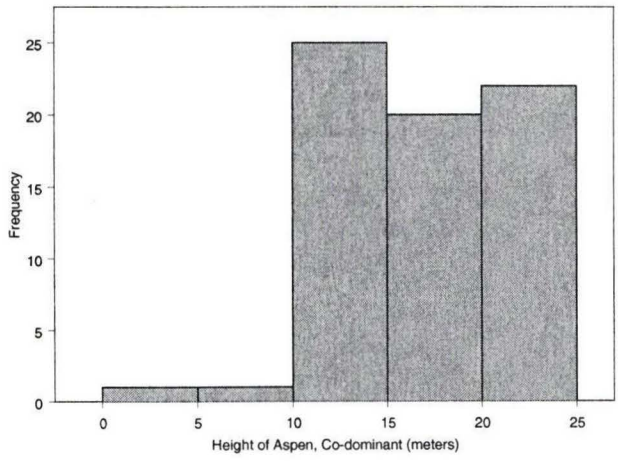
10
20
30
0
10
20
30
40
50
Conifer Canopy Closure (%)


Frequency
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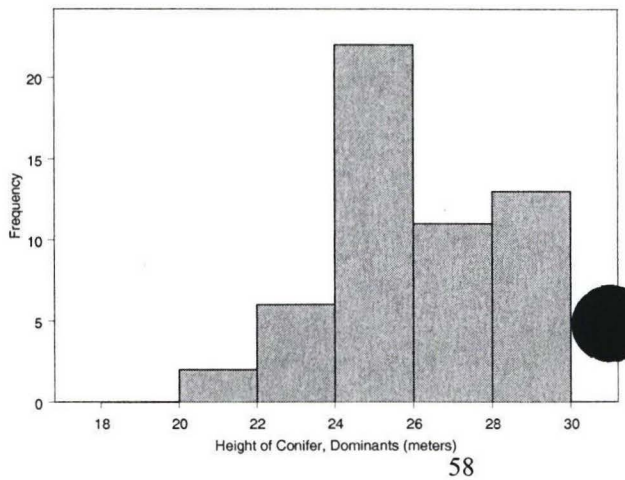
5
10
15
20
25
0
5
10
15
20
25
Height of Aspen, Co-dominant (meters)


Frequency
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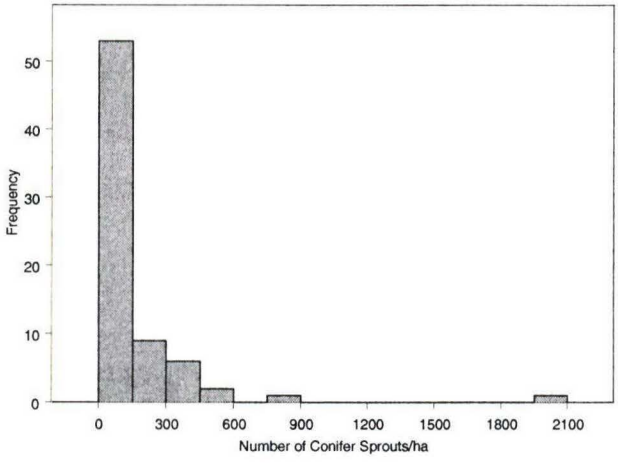
15
20
18
20
22
24
26
28
30
Height of Conifer, Dominants (meters)


Frequency
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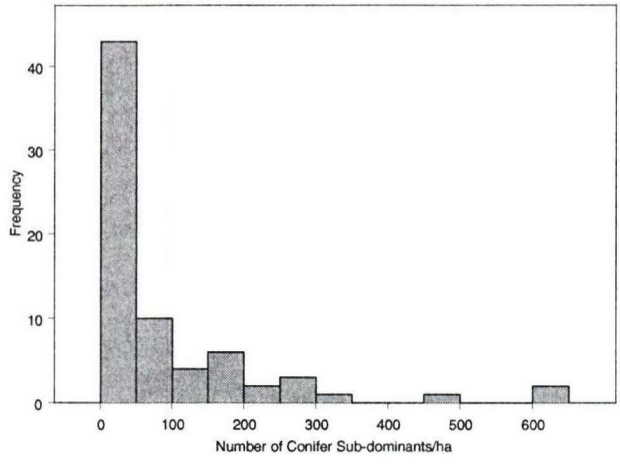
30
40
50
0
300
600
900
1200
1500
1800
2100
Number of Conifer Sprouts/ha


Frequency
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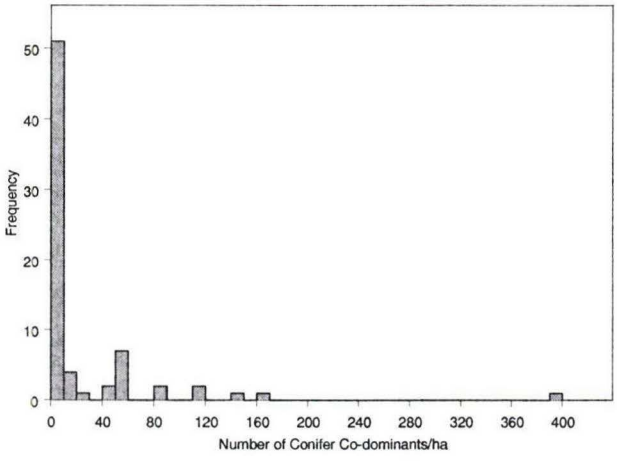
10
20
30
40
0
100
200
300
400
500
600
Number of Conifer Sub-dominants/ha


Frequency
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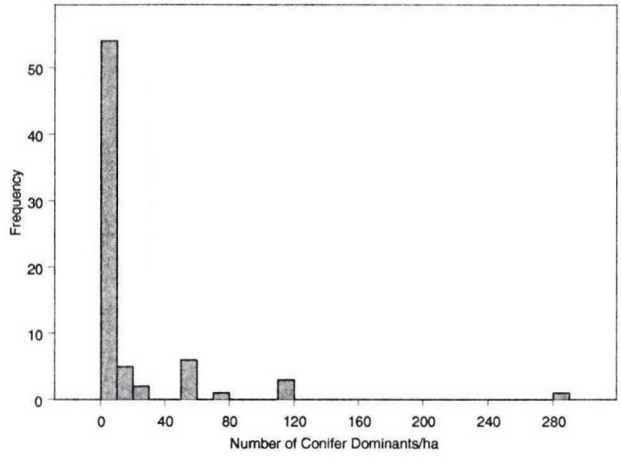
10
20
30
40
50
0
40
80
120
160
200
240
280
320
360
400
Number of Conifer Co-dominants/ha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30
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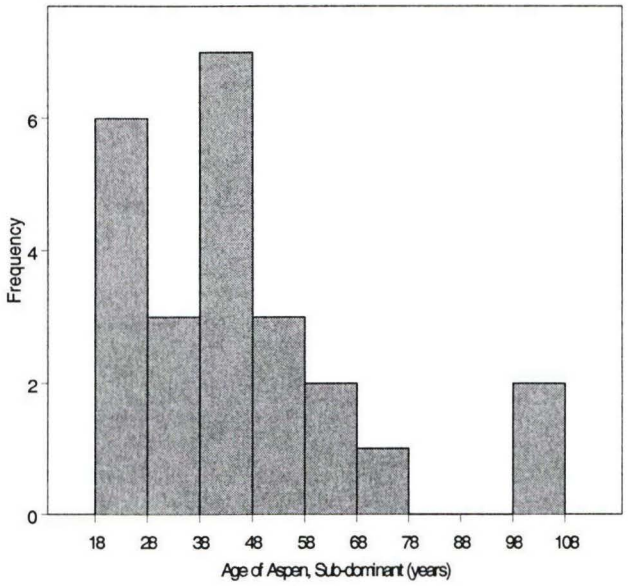
50
0
40
80
120
160
200
240
280
Number of Conifer Dominants/ha


Frequency
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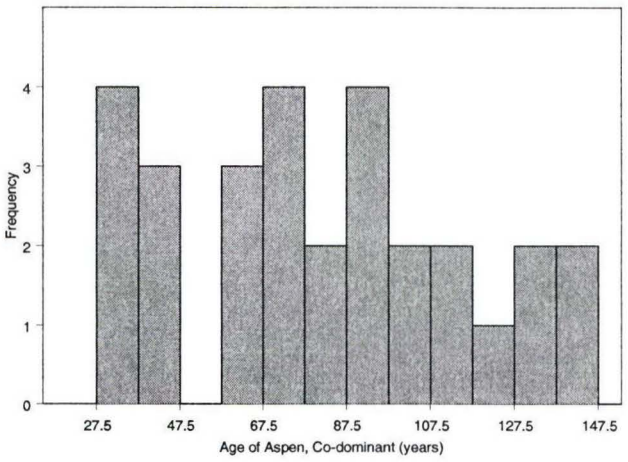
4
6
18
28
38
48
58
68
78
88
98
108
Age of Aspen, Sub-dominant (years)


Frequency
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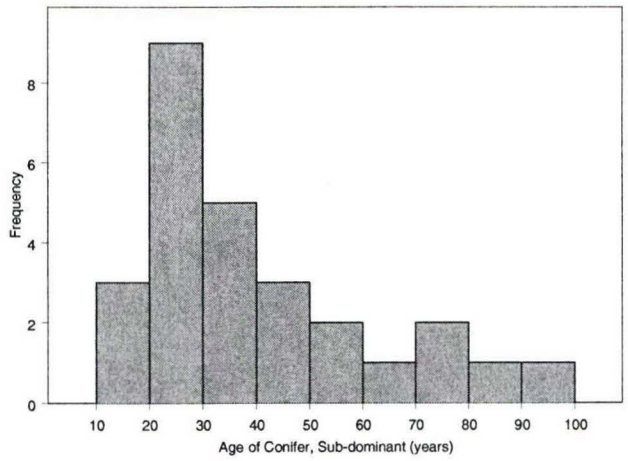
1
2
3
4
27.5
47.5
67.5
87.5
107.5
127.5
147.5
Age of Aspen, Co-dominant (years)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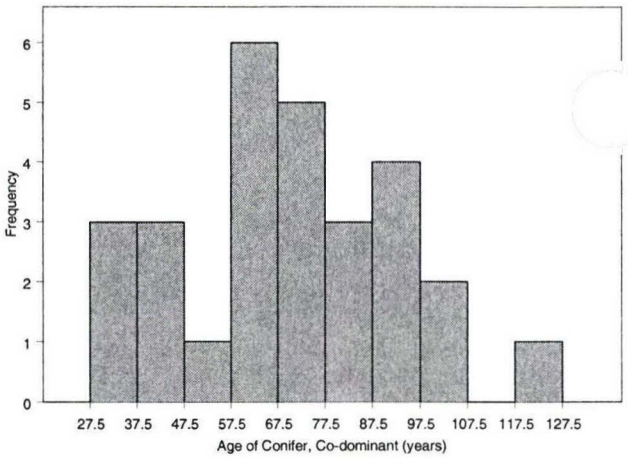
100
Age of Conifer, Sub-dominant (years)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97.5
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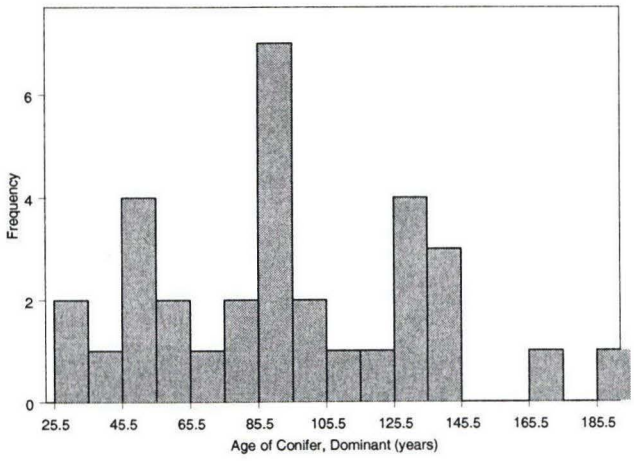
117.5
127.5
Age of Conifer, Co-dominant (years)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6
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45.5
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85.5
105.5
125.5
145.5
165.5
185.5
Age of Conifer, Dominant (years)

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